THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
James H. McGraw, Pres.
J. M. Wakeman, 1st Vice-Pres.
A. E. Clifford, 2d Vice.-Pres.
C. E. Whittlesey, Sec. and Treas.

John M. Goodell, Editor.

MAIN OFFICES:
239 WEST 39TH STREET, NEW YORK.
BRANCH OFFICES:
CHICAGO: Old Colony Building.
PHILADELPHIA: Real Estate Trust Building.
CLEVELAND: Schofield Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Cuba and Mexico............$3.00 a year
Canada..................................$4.50 a year
Foreign subscription.......................$6.00 a year
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.
Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.
REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.
CHANGE OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.
BACK COPIES.—No copies of issues prior to January, 1907, are kept on sale, except in bound volumes.
DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.
CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders, a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class Mail Matter.

Copyright, 1908, by the McGraw Publishing Co.

The circulation of THE ENGINEERING RECORD for 1907 was 763,000 copies, an average of 14,673 copies per week.
Of this issue 14,000 copies are printed.

TABLE OF LEADING ARTICLES.

The Engineer's Responsibility as an Expert........ 737
Central Station Power Problems.................... 737
The Encouragement of Tree Planting.............. 738
The Alberta Irrigation Project of the Canadian Pacific Railway Co. (Illustrated).................. 740
The Lock in the Charles River Dam, Boston (Illustrated) 742
Experiments with Air-Lifts (Illustrated)............ 745
Deepening a River Channel by Flushing............ 746
An Extensive Cofferdam of Steel Sheet-Piling (Illustrated) 747
The Operation of a 16-Inch Water-Main Siphon..... 748
Progress on the Ashokan Reservoir (Illustrated)... 749
Some Recent Steel Cage Buildings in San Francisco (Illustrated) 753
Construction of Section 903 of the Bridge-Loop Subway, New York City (Illustrated)................ 755
The Design of Retaining Walls.—I. (Illustrated).... 757
Notes on Two Recent Tests of Fuel Oil Pumping Engines 759
Heating and Ventilating Equipment for Storage Battery Buildings (Illustrated).................. 760
Living Conditions at Panama (Illustrated).......... 761
The Water Problem of the West.................... 763

The Engineer's Responsibility as an Expert.

Cases are known probably to most people of extensive acquaintance in which young men have declined to study law for the alleged reason that no lawyer is always professionally honest. This reason is given because a lawyer is supposed to adopt the point of view of his client and argue from it without regard to the abstract merits of the case. However that may be, the case of the lawyer as a professional man is, in fact, no different from that of an engineer or any other professional man who undertakes the care of a client's interest in a contest of any kind. It may be difficult at times to determine just where the engineer must assume the responsibility which lies upon any professional man of advising his client against what that client thinks to be his right or privilege, but such a point exists and it is one of the most delicate matters in an engineer's service to determine. And the lawyer occasionally finds himself similarly circumstanced in his professional work. It may be more frequently the duty of the engineer to assume the responsibility of acting counter to his client's apparent interest, but that is the most that can be said in the comparison of the two professional situations.

As human nature runs, the engineer like any other professional man will regard the conservation of a client's interest his first duty and it is only natural that his presumptions should favor those interests. No technical case, whether it be a matter of selection between two purely engineering questions, or whether it be the defence of a client's position as challenged by an opponent, is initially without balancing conditions which leave the issue to be determined in more or less doubt. It is at this point that the expert services of the engineer are required for the decision of the case, which may, and frequently does, involve large interests.

The question at once arises in the mind of the engineer whether the discharge of the desired expert duty will in any way compromise his engineering judgment or those technical views or opinions which he has acquired through an extended professional experience. It is not so very uncommon to find an engineer declining to undertake expert services on the ground that he cannot concur in certain views which are expressed by the client regarding perhaps the fundamental elements of the work or proposition under examination. Obviously no professional man can be expected to waive deliberately formed convictions or to violate even to a small extent well-established technical principles; but he should always consider most carefully whether the conditions of his case really traverse his own maturely formed convictions or those principles. These things are not always so obvious that a practitioner can determine with certainty his inability to handle properly the disputed interests of his client.

There is nothing unprofessional in the initial presumption of an engineer that a prospective client's interest justify professional defence, or in exerting his best efforts in making that defence even though there may be more or less doubt involved. In fact, that doubt is just what should be turned into a certainty in favor of the client if possible. If, on the other hand, it is clear that the technical position taken by the client is indefensible as an engineering proposition, any engineer would be recreant to his professional principles if he did not plainly and unqualifiedly advise that client of the erroneous position assumed by him. This is by no means an uncommon experience. There probably are few engineers who have had much consultation experience who could not name a considerable number of cases where the only true professional course has been to advise an emphatic negative to propositions where an encouraging affirmative was confidently expected. There is, however, no evading this kind of responsibility. As a professional man he is bound by the highest professional obligation to place his best judgment and knowledge at the service of those who seek him, whether the result favors the contemplated project or not. It is as much his duty to tell a client that he is wrong, if he is wrong, as to tell him he is right when he is right.

The same kind of responsibility attends a technical investigation, especially of a great public work whose effectiveness or safety has been called in question. It seems latterly to have become rather fashionable for irresponsible critics to assail the engineering character of large public works. In consequence of the public interest in such works, criticisms of this kind command a high degree of public interest, without much, or any regard to their origin. It matters little that a department of city government, for instance, may have a highly trained engineering organization to design and construct the works coming under its jurisdiction, or that its designs have been the result of most careful and elaborate study by experienced engineers. More or less public alarm is created by popular criticism, and investigations upon investigations must necessarily follow.

Again the engineer is called upon in an important contest to conduct an investigation which shall, if possible, clear the character of the doubtful structure or condemn it, as the case may be. Such responsibilities are as grave as any that an engineer has to discharge. The material interests involved are great and the professional obligation created is peculiar and delicate. In his investigation he is traversing the operations, presumably well done, of the engineers who have constructed the work, yet he must not fail to express the most positive criticism wherever, in his judgment, it is justified. On the other hand, it is natural that he should desire to allay public apprehension, if possible, by favorable comment. Unfortunately, there is occasionally a temptation to make capital of such circumstances not always successfully resisted, as public experience in New York City has recently demonstrated. These investigations of a purely technical character ought to be absolutely clear of every political feature or even the shadow of any untoward influence whatever. The responsibility of the engineer should be discharged to the last detail in a completely impartial and independent manner. It is his first and only duty to ascertain the exact facts in the case and to report them precisely as he finds them. His interpretations should be characterized by that good sense and sound judgment which come to the well-balanced and experienced practitioner. They should neither be those of an alarmist nor, on the other hand, should they condone negligence or incompetence. Under such circumstances, it is safe to say that the public may remain assured until positive evidence to the contrary is disclosed.

Central Station Power Problems.

Estimates of the cost of power based on the figures in the recently issued annual report of the Massachusetts Gas and Electric Light Commission indicate that the problems of central-station generation and distribution of current still demand the constant attention of steam and electrical engineers. The differences in cost, even among large companies, are so great that there is every incentive to study the question afresh. With the central station, low production cost is a vital necessity for the obvious reason that every fraction of a cent cut off the generating cost per kilowatt-hour is a direct economy, whereas with the electric railway, the saving of any cost in power is equally desirable on general grounds, but is, after all, an indirect economy, since transportation and not electricity is sold by the latter organization. In other words, it may pay the central station to devote relatively more attention to the power generation problem, including distribution, while the electric railway system may find other expenses of operation more important to reduce at first. Percentage reductions in the larger expenses lie first at hand in the comprehensive administration of an engineering system.

The Boston Edison Co.'s average station cost per kilowatt-hour of current generated reached the excellent figure of 0.83 cent, and in spite of the extent of its territory, aggregating probably 400 square miles, with the most remote distributing point about 25 miles away from the plant, the cost of distribution per kilowatt-hour sold averaged but 0.64 cent. These station costs included fuel, rentals of real estate and water power (not applying to the Boston company), oil and waste, water, wages at station, station repairs, steam plant repairs, electric plant repairs and station tools and appliances. The distribution expenses included wages for care of lights and meters, clerical labor in that department and payments to collectors, repairs and renewals of lines, meters, lamps and motors, distribution tools and appliances, carbons and incandescent lamps. The total power cost to the company, including office and management expenses, taxes and miscellaneous items came to 3.54 cents per kilowatt-hour. The percentage of generated energy lost in the distribution system was 23.8, measuring this from the station recording wattmeters to the consumer's meter.

But one of the other large companies in the State, the Lowell Electric Light Corporation, was able to produce current at the station for less than 1 cent per unit, except where water power was available. Lowell touched 0.98 cent; Worcester, 1.22 cents; Fall River, 1.4 cents; Malden, 1.07 cents; Cambridge, 1.05 cents, and Lynn, 1.2 cents. The coal consumption per kilowatt-hour figured 2.65 lb. at Boston; 3.12 lb. at Lowell; 3.46 lb. at Worcester; 4 lb. at Fall River; 3.46 lb. at Malden, and 3.22 lb. at Cambridge. Lynn used both coke and coal, preventing a direct comparison. In general, the cost of coal in this territory varies from $3 to $5 per ton, depending somewhat upon the distance from tidewater and the facilities for handling and storing it at the different stations. It is interesting to note that the cost at Lowell, the next station in economy to Boston, was about $5.

These differences show how attractive is the opportunity offered to bring the cost of current production down to a more uniform basis within the limits of a territory that is small enough for the expense of fuel, labor, material and supplies to be fairly comparable. The equipment characteristics and load factors of the different stations cited ought to be appreciated, of course, before final conclusions as to the efficiency of the plants are drawn. The Boston station is one of the larger turbine and engine plants of the East, designed with great care for economical production on a large scale, and with special facilities for the storage and mechanical handling of the coal supply. For the period covered by the above figures, the Lowell station, on the other hand, was not a particularly modern plant, and has, in fact, since been replaced by a new steam turbine installation. This company, however, is operated by one of the larger public service syndicates of the country, and presumably has the full benefit of a wide organizational experience under varied conditions. The Fall River plant has since been replaced by a new turbine station, and the plant at Worcester, still somewhat handicapped in production economy by the existence of certain line-shaft and belting equipment, is undergoing a gradual change to either direct-connected or turbine units, depending somewhat upon the company's experience during the next year or two. The Cambridge station is a well-organized and equipped plant with modern steam units, located on tidewater with good facilities for low cost of production. The Malden station is a remodelled station operated in harmony with the best ideas of a progressive syndicate controlling several other stations in Massachusetts.

The cost of distribution and total cost of current per kilowatt-hour sold were, respectively, 1.16 and 3.88 cents in Worcester; 0.84 and 2.96 cents in Lowell; 1.75 and 4.7 cents in Fall River; 1.97 and 4.7 cents in Malden; 0.78 and 2.83 cents in Cambridge, and 0.92 and 2.82 cents in Lynn. The greater portion of the power transmitted over any notable distance from the station in these cases was carried on 2300-volt circuits, although a certain amount of 500-volt motor service remains in some of these cities. In the case of the Boston Edison Co. it is probable that the potential of 6600 volts used on its longer transmissions is sufficient to allow a highly economical line loss, since the territory served by these lines is far from saturated from the standpoint of the carrying capacity of the principal circuits. As the natural growth of the suburban power and lighting business makes itself felt it is probable that the total cost of distribution on the Boston system will rise, although the steadying effect of a heavy underground service at low potentials in the business center of Boston will presumably keep the cost within reasonable bounds, provided the company maintains its present policy of systematically analyzing its distribution service losses at regular intervals. The smaller companies probably cannot expect in the long run to reach the distribution economies of organizations selling great volumes of current, for all the expenses of distribution other than line losses are not proportional to the amount of power sold. Size of plant is not the chief factor in low cost of power generation and distribution, although the large system can often afford to make more extended investigations of conditions that tend to prevent a company from realizing the best possible economy with a given plant design. The differences illustrated in the case of the companies cited point the way toward further needed analyses of power problems, if they do nothing else, for it is possible by improving the station load factor and by keeping the line losses down through the frequent use and interpretation of accurate instrumental records to better materially the efficiency of the plant as a whole. The periodical calibration of testing instruments and the wider encouragement of the motor load are both steps in the right direction. In a State so largely devoted to manufacturing as is Massachusetts the legitimate extension of electric power applications ought to far exceed the present development in not a few communities.

The Encouragement of Tree Planting.

The establishment of national forest reserves has received the support of a large majority of the influential people of the country, for in the last fifteen years there has developed a pretty general belief that our country is drawing upon its timber resources in a reckless manner that threatens bankruptcy in this respect before many generations have passed, unless remedial measures are taken at once. The purpose of establishing forest reserves was to prevent the reckless destruction of the more important great timber tracts belonging to the national government. It has been seen from the beginning of such work, however, that the preservation of existing virgin forests is a very small feature of a general plan of forestry to preserve what timber we now have and encourage the planting of more trees. Recently another factor has entered into the subject, which is regarded with apprehension by some people. This is the possibility of the establishment of a great national forest service, whose army of employees may develop into one of those governmental bureaucratic organizations that have a parasitic tendency to develop into something practically useless at the expense of the valuable service for which they were originally established. There can be no question but that the present Forest Service has done admirable work and deserves to be warmly encouraged in its endeavor to safeguard the national reserves and to spread throughout the country an interest in the preservation of trees and the reforestation of waste land. On the other hand, it cannot be denied that there is a growing opposition to this branch of the Department of Agriculture from those who fear the creation of a great force of employees engaged in forest work.

As a matter of fact, but little consideration is needed to show that something besides national supervision and encouragement is required to cover our waste land with forests like those which formerly protected them. Great pulp companies and lumbering corporations are already awake to the necessity of forest cultivation and preservation, and some of them have begun work on an extensive scale. Even if all of them were to use their utmost endeavor to conserve the forest lands belonging to them, all they could accomplish would be to provide for the future requirements of large individual consumers of timber. The smaller consumers must rely on other sources and it is the relatively small tracts upon which timber can be profitably grown that deserve special encouragement. Most engineers can recall rocky or sandy tracts where originally there was a growth of timber. Some of these were covered by spruce and pine, but after the original growth was cut down, nothing but hardwood grew in its place and in many cases even that was scrubby. We are all familiar with the barren. bushy hillside pastures, barely worth anything whatever for pasturage, but showing in an occasional woodlot how valuable they were at one time before they had been denuded of their trees. Land which is useful for agricultural purposes or for good pasturage need not be considered, in most parts of the country, in connection with tree planting and preservation, for there is an abundance of land worth very little for such purposes that can, nevertheless, be made to yield a return if planted with trees suitable for the climate and the soil.

In some sections of the country every farm contains some barren land. At the best it may be useful as very poor pasturage, but that is all. The farmer has to pay taxes on it, and if anyone suggests to him that the planting of trees on this waste land would yield him a larger income at the end of thirty years or forty years than its use as pasturage, the suggestion would be met with ridicule on the ground that no farmer cared to wait thirty years for a return upon his labors. The use of that land as pasturage brings in comparatively little return to the State, however, while its use as timber land would be decidedly profitable, since anything which will tend to keep down the price of good timber, now soaring upward in cost at a painfully rapid rate, will be to the material advantage of all citizens. There are many tracts where spruce and pine can be grown that now are used simply as poor pasturage, being employed for the latter purpose simply because the farmer has to pay taxes on the land and he wants to get something back from these taxes if possible. The situation must be faced that he will not plant trees without some form of encouragement, and so the suggestion has been made that the several States should encourage the development of timber tracts by exempting from taxation all land on which trees are set out. If a man must pay taxes on land unless he plants trees on it, the chances are that a good deal of such work will be done. The details must be worked out with some care, of course, so as to insure the selection of proper trees for a given locality and their planting in a suitable manner. It would also probably be necessary to exercise some supervision over the wood lots and timber tracts developed under such a law, but this supervision would be done by representatives of the various States and not by a single great national forest bureau, and thus the dangers which some critics see in the latter organization would be avoided.

The advocates of this method of encouraging replanting do not intend that land set out to trees shall remain entirely free from taxation for all time, but they propose that when the timber is sold a certain proportion of the price shall be paid over at that time to the State in lieu of the annual taxes ordinarily levied. This suggestion does away with the objection raised against the plan when it was first suggested, that it is contrary to our principle that all taxes should be uniform. If the final charge made against the timber when it is sold is adjusted reasonably, it will probably amount to such a small percentage of the total selling price of the timber that the planting of the trees will have proved a profitable use of the land. The plan is not original with The Engineering Record, but has been developed by those who have been paying much attention to the forestry needs of the country. It has been discussed a good deal privately and is now published for the criticism of all who feel concerned in the development of our timber resources. Something certainly must be done to encourage tree planting, and this journal will be glad to receive criticisms of this plan and suggestions for other methods of meeting the growing scarcity of our wood supply.

Notes and Comments.

The Cut in Steel Prices, long expected, was made this week in conformity with the inexorable operation of the law of supply and demand. The prices on sheet and tin plates were reduced earlier in the year, and consequently no change was needed there. The quotations on steel rails are also unchanged, for the recent raising of the standard requirements for this product has increased the cost of its manufacture and the railway companies and steel mills have already practically agreed on the price and quality of rails for some time to come. The changes agreed to by the United States Steel Corporation and the leading independent mills provide for a reduction on billets from $28 to $25 a ton at Pittsburg, on sheet bars from $29 to $27 at Pittsburg, on plates and structural steel from 1.7 to 1.6 cents at Pittsburg, on merchant pipe a reduction of $4 at Pittsburg, and on wire nails from 2.05 to 1.95 cents. The official announcement of these changes concluded: "It is hoped that these changes will not necessitate a general or radical readjustment of wages, which it is desirous to avoid." This cut is manifestly a wise move, for it will prevent a war among the mills that would profit nobody in the end. The policy of maintaining uniform prices for staple products through seasons of active and slack demand is one of self-evident merit, for it steadies the business conditions of all purchasers of steel as well as those of the mills themselves. A time will come in every industry, however, when it is necessary to distinguish between a steadying of the market and a uniform raising or lowering of all prices. The situation is like that which arises in a power plant; the governors of the engines will steady minor fluctuations, but when a marked variation arises in the demand for power the station operators must readjust the running conditions. The necessity for readjustment has arisen in the steel industry all the way from the jobbers, wholesalers and mills to the ore producers, who, it is understood, have accepted a reduction of 50 cents a ton on their output. The result of this reduction is that all users of steel will be assured of the same steadiness in prices which they have experienced of late and at the same time will be able to supply their needs at prices in harmony with the general trade conditions.

The Hudson River Bridge project for constructing a structure between the New Jersey Shore and Manhattan Island is again before the public, for there will be hearings shortly by a joint commission of the two States to listen to arguments concerning the site of the bridge and other matters in which the public is directly interested. The New York members of the last joint commission reported that a location somewhere between 14th and 72d Sts., Manhattan, would best serve, but since that report was made, a great deal of sentiment has been aroused for the location of the structure in the neighborhood of 169th St. If placed so far north as this, the attractive boulevards on both banks of the river could be connected in such a way as to afford a magnificent drive, and the facilities for handling suburban residents by electric railways into New York could be greatly extended. The location of a bridge so far north would have unquestionably a very great effect on real estate development on both sides of the river, but whether this future development warrants the construction of such an expensive bridge at that place is a question certainly open to debate. It is interesting to notice that the new commission is authorized to consider tunnels as well as bridges. This choice of a means of connection between the New Jersey and New York shores is likely to arouse again the old controversy between the tunnel enthusiasts and the bridge specialists. The time has probably gone by, however, when it is reasonable to claim that tunnels will answer all the purposes of bridges. They certainly have their field of usefulness, which is a very large field, and their comparatively low cost is in their favor, but long-span bridges permit the handling of such an enormous amount of traffic that they will always be useful where the volume of travel that can be concentrated at one river crossing is large.

A National Conservation Commission was appointed this week by President Roosevelt in accordance with the suggestion at the recent gathering of Governors at the White House to discuss methods of utilizing in the best manner the resources of the country. The chairman of the executive committee is Mr. Gifford Pinchot, of the Forest Service, and the other members include various Congressmen, engineers and government employees. The commission is divided into four sections, one of them relating to waters and directed by Mr. T. E. Burton, chairman; a second devoted to forests and under the chairmanship of Senator Reed Smoot; a third devoted to lands and under the chairmanship of Senator Knute Nelson, and a fourth devoted to minerals and under the chairmanship of Representative Dalzell. This commission is to advise the President on questions relating to the conservation of the natural resources of the country and to co-operate with similar bodies which may be appointed by the various States. There can be no question that the natural resources of the country deserve to be the subject of prolonged and careful study, for their complete economical utilization will be of great benefit. The potential value of these resources is enormous and it is undoubtedly true that in the past many uses have been made of them to the sole advantage of private parties when some return should have also been made to the government. We know so little of these things at the present time that anything which will increase our store of accurate knowledge is to be welcomed. On the other hand, if the real purpose back of these conferences has been to suggest the removal of the charge of the improvement of our rivers and harbors from the War Department and its Corps of Engineers, the subject takes on an entirely different aspect and must be discussed from a different point of view. It is a pity that no authoritative denial has yet been published of this common report concerning the control of river and harbor improvements.

The Durability of Construction Plant is something which is deserving of constant attention from manufacturers of such equipment. It is not always the contractor's fault if he endeavors to use a steam shovel, for example, on material which is too hard for the machine he is working; the salesman is sometimes at fault for recommending a machine too light for the work. Dump cars which are used for both earth and rock must be strong enough to withstand the impact of heavy masses of the latter material falling a considerable distance. If one detail of them breaks down under the shock the cars are almost as useless for the time being as if they fell apart like the deacon's one-horse shay. This is particularly true on most construction undertakings, because repair facilities on them are likely to be extremely meagre. Most companies manufacturing equipment take pride in turning out only durable appliances, yet no appliance is so strong that it may not be put to an unexpected use, which will develop in it weaknesses for that kind of service. When a condition of this sort arises and work is held up until equipment can be improved, those manufacturers who show the most interest in studying the cause of the trouble and remedying it are likely to be favored when orders for new equipment are placed. This seems so self-evident as to be trite and unworthy of utterance, yet recent observations on a large construction undertaking show that there is ground for calling attention to the fact. It makes no difference what cause is responsible for putting equipment out of service, other than the incompetence of those using it, so far as the contractor is concerned; the delays in carrying on work owing to the failure of primers to explode, or the breakage of dump cars or the failure of some part of a steam shovel, mean so much to those responsible for pushing the work that those manufacturers who show an immediate interest in the cause and repair of troubles of this sort become far more popular than those who merely write letters of condolence. The tendency of the times is to put equipment to harder and harder service, and whenever a machine develops a weak spot under such conditions, it is to the maker's advantage to strengthen it at once.

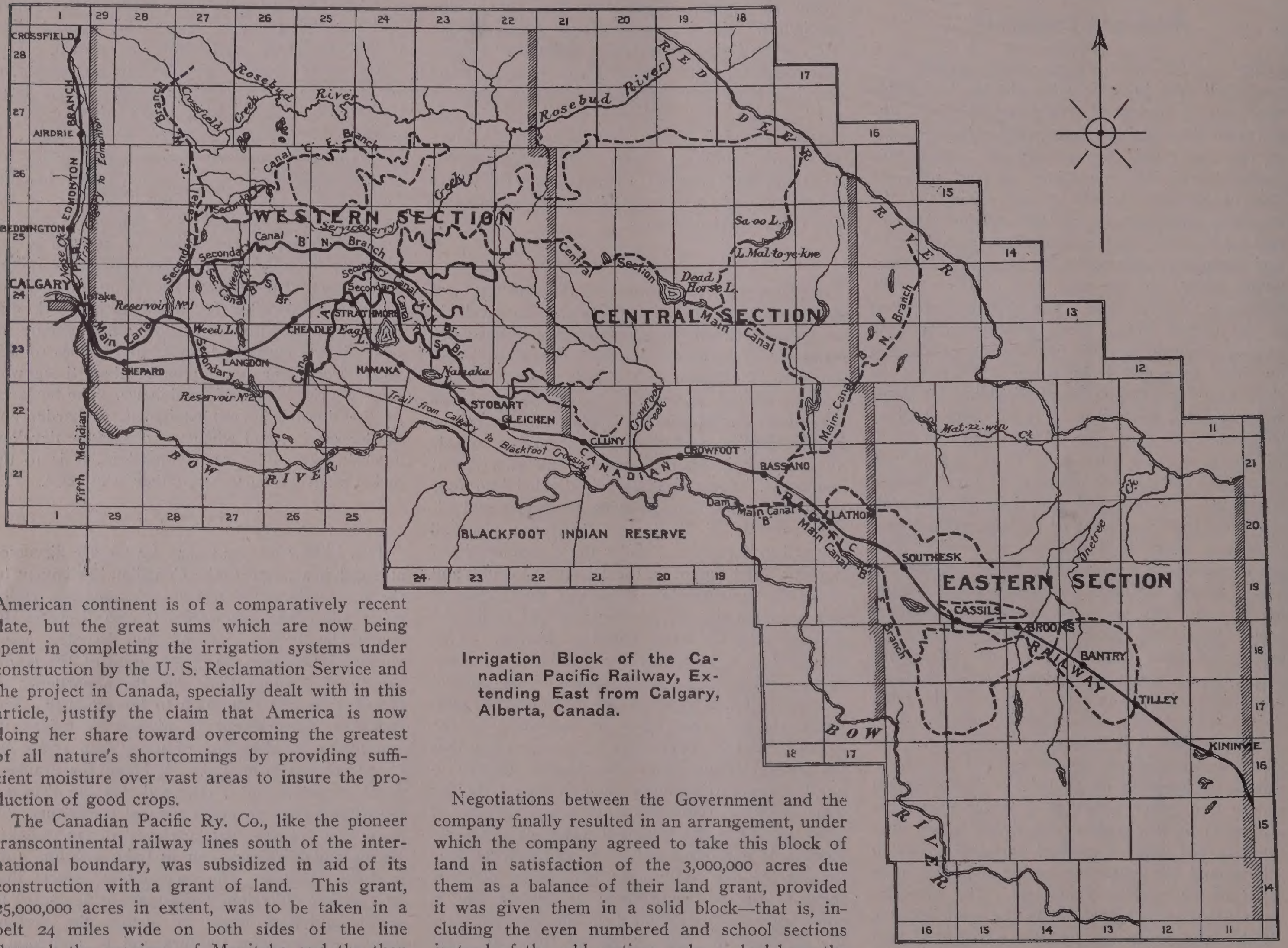
The Levels of the Great Lakes are discussed at length in a report to the Canadian Parliament by the International Waterways Commission, which was made public last week. It also discusses the contemplated extension of the drainage canal works of Chicago, the preservation of the scenic beauty of Niagara Falls and the exportation of power from the Dominion to this country. The Canadian Government is advised to refuse its consent to the diversion of more than 10,000 cu. ft. per second from Lake Michigan for drainage canal purposes, and it is stated that the abstracting of this amount, under present conditions, will lower the average surface elevation 6 in. in Lakes Huron and Michigan, 5 in. in Lake Erie and 4 in. in Lake Ontario. The commission asserts that any further diversion would make it necessary to spend enormous sums to restore the present depths in Canadian harbors and to maintain a uniform draft of 14 ft. in the Canadian canal system, while the restoration of present navigation conditions in American harbors and channels would also call for vast sums. The regulation of the level of Lake Erie by a dam or dams in the Niagara River should not be permitted, the commission reports, unless provision is made for preventing any lowering of the levels of Lake Ontario and the St. Lawrence River. So far as the diversion of water for power purposes at Niagara Falls is concerned, the commission makes the direct statement that "it would be a sacrilege to destroy the scenic effect of the falls." The opinion is reached that more than 36,000 cu. ft. per second on the Canadian bank of the river and more than 18,500 cu. ft., including diversions for the Erie Canal, on the American bank, cannot be taken from the stream without injury to the falls, and should be prevented by treaty.

THE ALBERTA IRRIGATION PROJECT OF THE CANADIAN PACIFIC RAILWAY CO.

By J. S. Dennis, Mem. Can. Soc. C. E., Assistant to the Second Vice-President and Chief Engineer in charge of Irrigation Project, Canadian Pacific Ry. Co.

In all portions of the habitable globe government or corporate interests have undertaken great public works, with the object of providing or improving rail or water communication, improving sanitary conditions or preventing floods, but no work to overcome nature's shortcomings has been completed by either of these interests that has had the same transforming influence upon the ultimate development and prosperity of a country as the irrigation projects of India, Egypt and the United States, and to these may now be added the vast project which the Canadian Pacific Ry. Co. has in hand in Alberta, Canada.

The modern irrigation development on the American continent is of a comparatively recent date, but the great sums which are now being spent in completing the irrigation systems under construction by the U. S. Reclamation Service and the project in Canada, specially dealt with in this article, justify the claim that America is now doing her share toward overcoming the greatest of all nature's shortcomings by providing sufficient moisture over vast areas to insure the production of good crops.



Irrigation Block of the Canadian Pacific Railway, Extending East from Calgary, Alberta, Canada.

The Canadian Pacific Ry. Co., like the pioneer transcontinental railway lines south of the international boundary, was subsidized in aid of its construction with a grant of land. This grant, 25,000,000 acres in extent, was to be taken in a belt 24 miles wide on both sides of the line through the province of Manitoba and the then Northwest Territories, now comprising the provinces of Saskatchewan and Alberta.

Under the terms of the contract the company was not required to take lands within this belt which "were not fairly fit for settlement," and, construing this as giving them the right to reject lands in districts where the question of insufficient rainfall cast some doubt upon crop production, the company refused to accept some millions of acres of land in the southern portions of the provinces of Saskatchewan and Alberta, and was granted lands in lieu thereof in the northern portions of those provinces. When the question of the final adjustment of the land subsidy came up there was a balance over and above what had been located and selected of some 3,000,000 acres due the company, and much negotiation took place with the government as to where this land was to be located.

After the rejection by the company of land in southern Saskatchewan and Alberta the Government for several years carried on, under direction of the writer, a system of general surveys to indicate whether any considerable portion of the rejected lands could be irrigated and what water supply was available for that purpose. These surveys demonstrated that along the Canadian Pacific Ry. line in southern Alberta, immediately east of the Bow River, there was an area of some 3,000,000 acres, one-half of which could probably be irrigated with water diverted from the Bow River, and that there was sufficient water in that stream for the purpose.

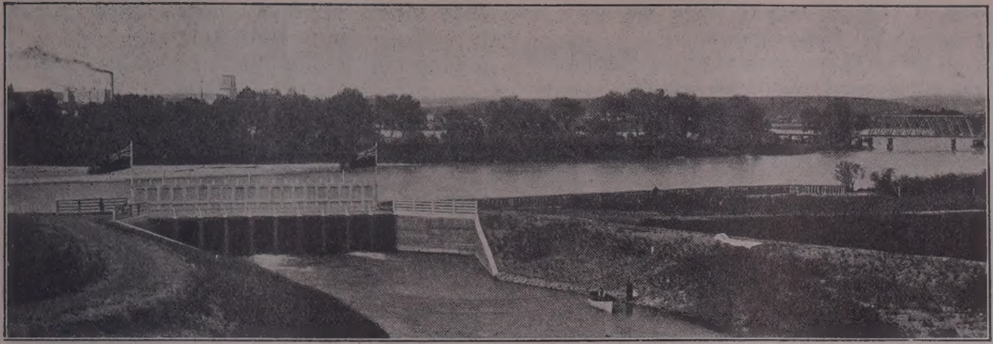
Negotiations between the Government and the company finally resulted in an arrangement, under which the company agreed to take this block of land in satisfaction of the 3,000,000 acres due them as a balance of their land grant, provided it was given them in a solid block—that is, including the even numbered and school sections instead of the odd sections only, as had been the rule in the rest of the grant, and this is the block which is now being developed by the construction of the great irrigation system which the company has undertaken.

The area embraced in this block, as it is commonly called, is bounded on the west by the fifth meridian, on the east by the line between Ranges 10 and 11, west of the fourth meridian; on the south by the Bow River, and on the north by the Red Deer River and the north boundary of Township 28. It has a length from east to west of 150 miles, an average width north and south of 40 miles, and its magnitude may be illustrated by stating that it is larger than the states of Connecticut and Rhode Island combined, twice as large as the province of Prince Edward Island, one-eighth the size of England and Wales, about the same size as the Hawaiian Islands and twice the size of Porto Rico. The area of land to be put under irrigation within the block is four times as large as the irrigated area of the state of Utah, about equal to the total irrigated area of the state of Colorado and nearly one-sixth of the total irrigated area of the United States.

The block is an open prairie plateau, with a general elevation at its western boundary of 3,400 ft. above sea level and slopes rapidly to the east until an elevation of 2,300 ft. is reached at the eastern boundary. The surface throughout is more or less rolling until the eastern section is reached, when large areas of almost level plains are found. The soil is good, with a heavy black loam and clay subsoil in the western portion, and a lighter sandy loam, with good subsoil, in the more easterly portions.

The portion of southern Alberta within which this vast block of land is situated is not arid in the sense that nothing can be raised without irrigation. The average rainfall for a series of years has been about 15 in., but this moisture is not always available at the time when it is needed by the growing crops, and it is realized that without irrigation certain crops cannot be raised, and that in any year the certainty of crop production is assured by having water available to irrigate when necessary.

The preliminary surveys made by the Government had in a general way proved that a large portion of the block could be irrigated, and the water was available from the Bow River, which bounded the block on the south. After acquiring the block the company carefully considered the results to be obtained from the construction of a comprehensive irrigation system, and finally in 1903 undertook the extensive and detailed surveys necessary to indicate how the scheme should be developed and its approximate cost. Construction work was commenced in 1904 and, together with



Headgates of Main Canal A, near Calgary.

the extension of detailed surveys, has been going on ever since.

In developing the scheme the block was divided into three sections, Western, Central and Eastern, containing about 1,000,000 acres each, and the construction of canals and incidental colonization is being carried on along the lines of development of the sections in the order named.

The general engineering surveys completed indicate that about 1,400,000 acres in the whole block can be irrigated, of which 350,000 acres are situated in the western section.

The water for the irrigation of land in the western section is diverted from the Bow River at a point about two miles below the city of Calgary. From thence it is carried south and east through a main canal, 17 miles in length, which has a bed width of 60 ft., side slopes of 1½ to 1 and carries water to a depth of 10 ft. This main canal delivers the water to a reservoir, for which a natural depression has been utilized and where, by the erection of a dam 1,500 ft. in length and 30 ft. high, a body of water three miles in length, half a mile in width and 40 ft. deep has been impounded.

From this reservoir the water is taken out in three secondary canals, A, B and C, and carried to the different districts to be irrigated. These secondary canals have a bed width at their upper end of 20 to 30 ft., carry water to a depth of 8 ft., and their combined length is 150 miles. From the secondary canals the water is again diverted and distributed through a comprehensive system of distributing ditches, which deliver the water to each quarter section, or 160 acres of land, to be irrigated, the combined length of these distributing ditches in the western section being 800 miles.

The construction work in the western section will be well advanced toward completion with the close of the present season, and the mileage of waterways constructed by the company in this section will then stand as follows: Main canal, 17 miles; secondary canals, A, B and C, 150 miles; distributing ditches, 800 miles; total, 967 miles. In addition, there will be several hundred miles of the small distributing laterals constructed by the farmers to distribute the water over their farms.

In completing the work in the western section the following amount of excavation will have been moved: Main canal, 2,500,000 cu. yd.; secondary canals, A, B and C, 5,000,000 cu. yd.; distributing ditches, 1,750,000 cu. yd.; total, 9,250,000 cu. yd. Several thousand structures, consisting of headgates, spillways, drops, flumes, measuring weirs, highway bridges and culverts, have been built in connection with the distribution of water in the western section, 8,190,000 ft. B. M. of timber and 83,000 lin. ft. of piles having been put in place in connection with the erection of these structures.

The first intention in developing the general scheme was to divert water for the irrigation of the central and eastern sections of the block by a second main canal heading in the Bow River at a point about 60 miles east of Calgary, but the detailed surveys have proved that it will be better to provide the water for the central section by enlarging the main canal and secondary canal B in the western section and to transport the water through these enlarged channels to the central section, supplying only the eastern section through the second main canal heading in the river at the lower point referred to.

View of Main Canal A, Western Section of Irrigation Block.

The general surveys indicate that it will be necessary to provide about the same percentage of waterway and structures in the central and eastern sections as has been built in the western section, and the completed scheme will therefore stand about as follows:

Mileage of main canals	51 miles
Mileage of secondary canals	450 miles
Mileage of distributing ditches	2,400 miles
Total	2,901 miles
Excavation to be completed, in cu. yd.	27,750,000
Timber to put in place, in ft. B.M.	26,000,000
Piles to put in place, lineal feet	250,000
Estimated total expenditure	$8,000,000

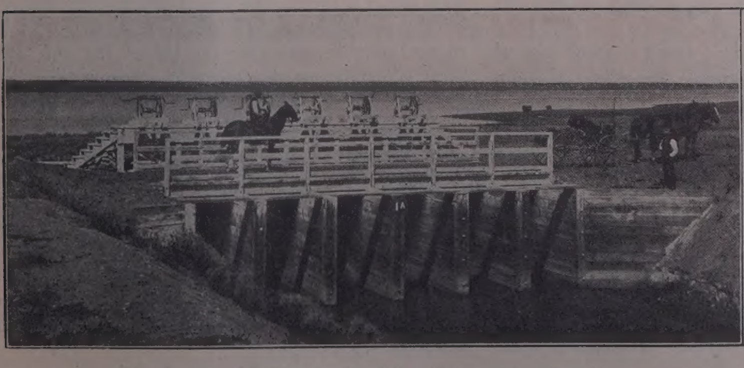
Engineering Features.—The main difficulty that had to be overcome from an engineering standpoint in projecting this extensive system of irrigating canals and ditches was the excessive general slope of the country, which, it will be noted, has a difference in elevation at the eastern and western boundaries of the block of 1,100 ft. In the western section this has been provided for in the main and secondary canals by the construction of a series of drops and also by the utilization in certain cases of natural channels, down which water is carried without any attempt to check the flow resulting from natural grades. On many of the distributing ditches, however, the excessive natural slope of the country has caused trouble in location and has in some instances necessitated these ditches being carried on a drop line for long distances.

The main canal constructed to supply water for the western section and the secondary canals which distribute the water have so far all been located and constructed without the introduction of any high flumes, and, with the exception of the dam which creates the reservoir at the east end of the main canal, this portion of the system is singularly free from any structures which by failure could cause trouble or interrupt the supply of water.

In extending the canal system to the central and eastern sections several important structures will be required. The water for the central section taken, as already explained, through an enlargement of the present canal system in the western section, will have to be delivered through a flume, 1,700 ft. in length and 60 ft. in height, and at the point of intake for the main canal to supply water for the eastern section a dam will have to be constructed in the Bow River 700 ft. in length and 40 ft. in height.

The distribution of water in the central section will be from a reservoir which can be created at Dead Horse Lake. By utilizing this lake bed and adjacent valleys some 240,000 acre-feet of water can be stored without the construction of any extensive dams.

Owing to the fact that this system is being built by the railway company owning the railway line which traverses the block from east to west and the further fact that in many instances the canals run alongside the railway line, cross the

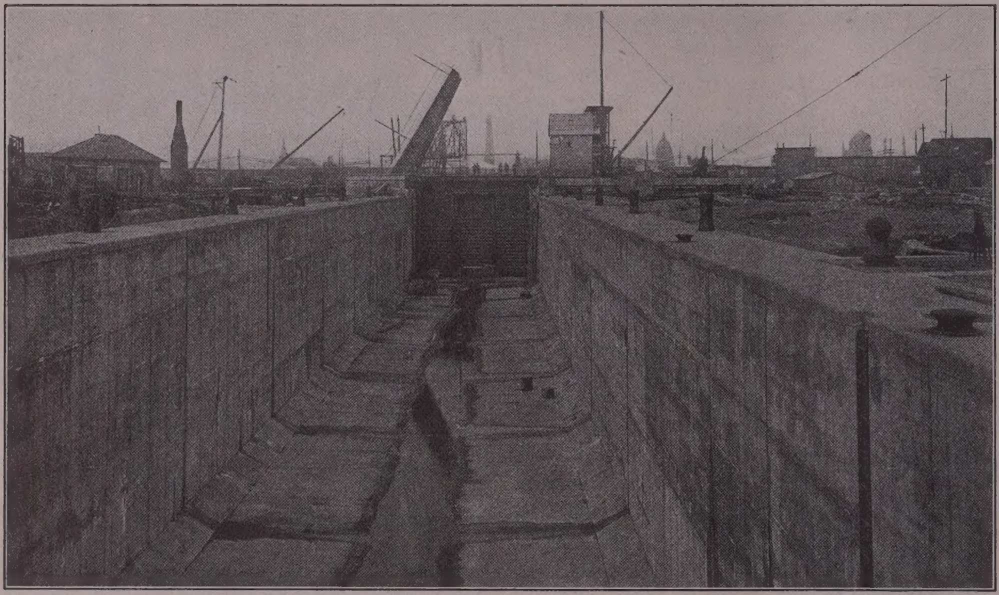


Reservoir and Headgates of a Secondary Canal.

Irrigated Field, with View of Typical Country.

line at numerous points and at other points are at a much higher elevation than the railway grade, special attention in the design and construction of the system is being given to the matter of preventing possible interruption to railway traffic owing to breaks in canal banks. All banks on important canals and where dams have been formed have been built in successive layers, properly spread, rolled and sprinkled, and, while this has added materially to the cost of the work, it has resulted in exceptionally compact and uniformly solid banks and a total absence of any leakage or seepage which might cause trouble to railway traffic.

In designing and constructing this project the company has departed from the usual engineering practice on this continent of building only the main and secondary canals to deliver the water to the area to be irrigated, as a whole, and then leaving it to the purchasers of the lands to get together and build the distributing ditches to supply water for the irrigation of the individual farms. In this undertaking not only the main and secondary canals are built, but also the vast system of distributing ditches so as to provide for the delivery of the water at some point on each quarter section of land offered for sale. The purchaser can see on the map from which he buys his land exactly where the water is to be delivered to him, and these maps also show, from actual contour surveys, the area which is irrigable on each quarter section. These provisions have necessarily added immensely to the engineering work of the project, but they overcome any future difficulty as to areas that are irrigable or questions connected with delivery of water to the individual purchasers.



The Lock in the Charles River Dam, Boston.

This irrigation undertaking, which, from the standpoints of area included in the block, area to be actually irrigated and mileage of canals and ditches constructed, is America's greatest individual irrigation project, was undertaken by the Canadian Pacific Ry., with the object of transforming a vast area at present unsettled and non-traffic producing into a closely settled and prosperous farming community, with the attendant heavy traffic that always results from such districts. The company does not expect to make any profit out of the irrigation undertaking itself, and in fixing the price of the land for sale is adding to the value of the land in its wild state simply the cost per acre of bringing the water to the land. In addition, the company has fixed the annual charge per acre for maintenance of the works at the low price of 50 cents, so that the ultimate profit from the undertaking, aside from the sale of the land on a dry-land basis, must be derived from the traffic which the block will produce when fully colonized.

So far about 300,000 acres of non-irrigable land and 100,000 acres of irrigable land have been sold, the prices of the former ranging from $7 to $15 per acre and of the latter from $18 to $25 per acre. The colonists that are taking up land come from all quarters of the globe, but the majority are a sturdy class of pioneer settlers from the United States in search of cheap lands and new home-making possibilities.

The colonization so far effected has been on a basis of about 100 acres to a family, as compared with the general average of about 300 acres in other portions of western Canada. If this average is maintained over the whole block it will readily be realized what a large farming community will ultimately be created, and, with the large urban population which must necessarily result from such intensive agricultural settlement, this 3,000,000-acre block will become one of the most closely settled farming areas of the West.

The crops that are raised consist of wheat, oats, barley, flax, alfalfa, timothy, clover, sugar beets and vegetables of all kinds. The country is also specially adapted for dairy farming and cattle; horses and sheep graze at large during the majority of the winters.

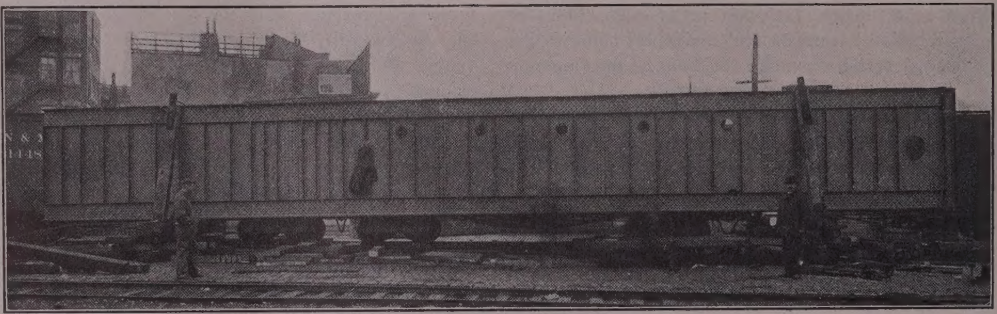
The development of the project is in charge of the writer as chief engineer for the Canadian Pacific Ry. Co.

A Tunnel Accident recently the subject of a suit before the Oregon Supreme Court has resulted in a decision, 95 Pac. Rep., 196, that where a servant is employed in a tunnel the master must use reasonable care to make his place of work as reasonably safe as the nature of the work permits; but, if it is the workmen's duty to shore up or make the place safe as the work progresses, the master's duty is fulfilled when he furnishes suitable material for that purpose.

The Lock in the Charles River Dam, Boston.

By Walton H. Sears, Mechanical Engineer, Charles River Basin Commission.

The legislative act authorizing the construction of a dam across the Charles River between the cities of Boston and Cambridge, Mass., provides for the construction of the dam, of a marginal conduit on the Boston shore, of a similar conduit on the Cambridge shore and certain dredging, all to be done by the Charles River Basin Commission. It also provided for the construction of an embankment and park on the Boston side to be done by the city of Boston, but this work, under a subsequent act, was also transferred to the above commission. The act fixes the height of the dam "as sufficiently high to hold back all tides and to maintain in the basin above the dam a substantially permanent water level not less than 8 ft. above Boston base." It further fixes the location at the site of Craigie Bridge.



One of the Lock Gate Girders.

Under these conditions there will be formed an inland lake of fresh water, about 8 miles long and ½ mile wide at the widest point, having an area of about 1¼ square miles, with a water level about 2.6 ft. below mean high tide.

This means that the dam will take pressure from the harbor side at times, and at other times from the basin side, and makes it necessary to take care of the flow of the river, when the upland flow is in excess of the evaporation from the basin, by positive-acting sluice gates. There have been provided for this purpose eight gates with 7.5 x 10-ft. openings.

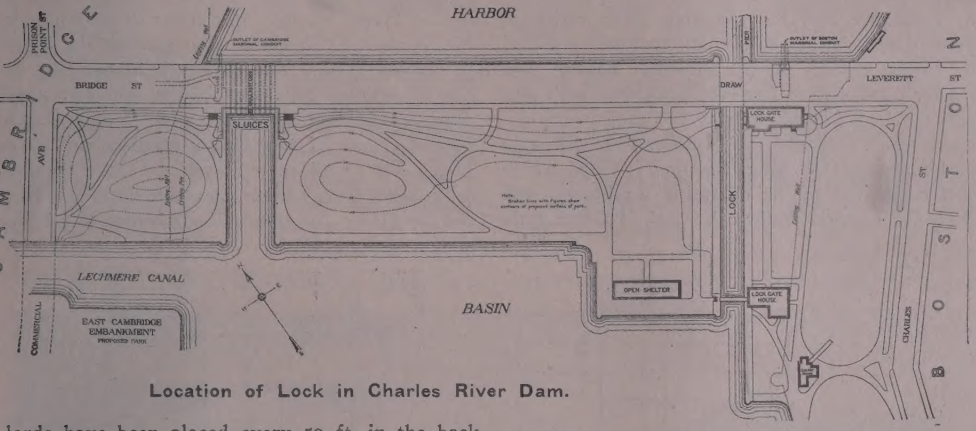
The sluices, wherein these gates are placed, are at the Cambridge end of the dam and the masonry for them was placed inside a cofferdam. At the Boston end is located the lock, also constructed in a cofferdam. Between these two masonry structures is to be an earth dam some 850 ft. long, placed between masonry retaining walls on the harbor and basin sides. The general plan of the dam is shown in an accompanying illustration, and the scope of the work has been described in The Engineering Record of July 9 and Nov. 26, 1904, and March 3, 1906, the latter article containing a description of the construction of the cofferdam for the lock and of the dredging and foundations for the lock.

The object of this article is to provide a description of the lock and its appurtenances. The lock is 45 ft. wide and has a depth over the sill of the downstream lock gate of about 17 ft. at mean low tide, and over the sill of the upstream gate of 21 ft. at the normal basin level. The length is 351 ft. 6 in. in the clear between gates.

A typical section of the masonry was shown in The Engineering Record of Nov. 26, 1904, and an accompanying photograph, taken from the top of the stop planks at the upper end, gives an excellent idea of the appearance to-day. The entire structure is founded on piles, except a small portion at the upper end, where hardpan was encountered. The concrete was placed in sections about 40 ft. long, expansion joints being provided between the sections.

For the purpose of carrying telephone and other wires, there are imbedded in one of these sections sixty 4-in. wrought-iron pipes passing under the lock in long radius bends from five manholes on one side to the same number on the other side.

It is planned to assist vessels through the lock by power furnished by capstans, and two of these have been installed on the Boston side of the lock, one near each end. Provision, too, has been made in the concrete for the installation of four more capstans, three on the Cambridge side and an additional one on the Boston side, intermediate between those now in place, should it be found necessary so to do. For snubbing, bollards have been placed every 50 ft. in the back of each lock wall.



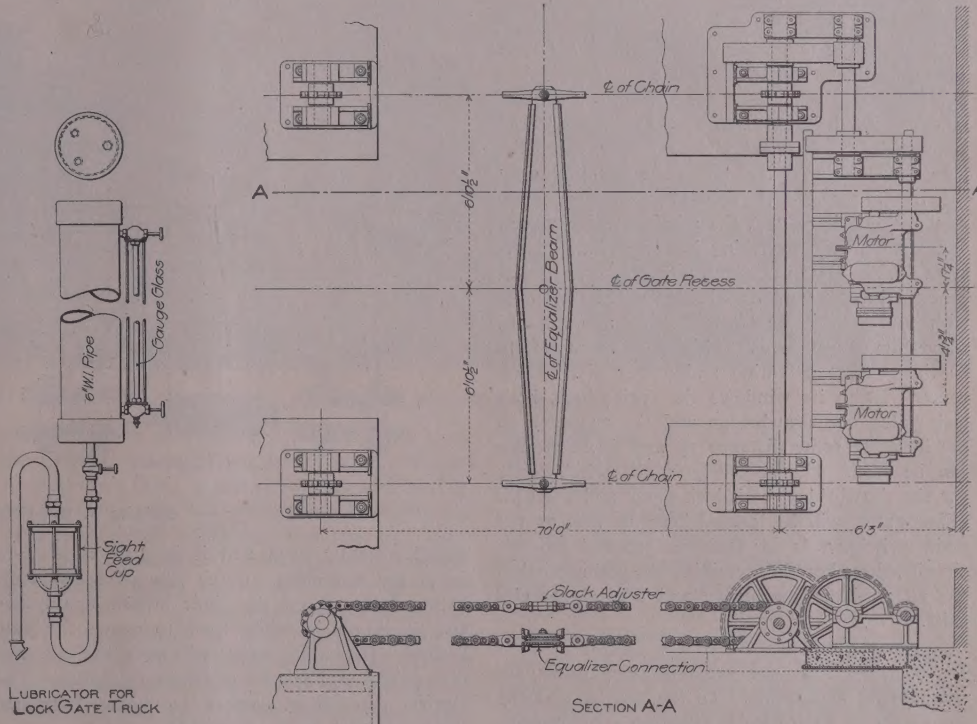
Location of Lock in Charles River Dam.

For pumping out the lock, which may be stop-planked, a 24-in. Worthington vertical volute pump, direct connected to a 150-h.-p. General Electric variable-speed motor operating at 500 volts direct-current, has been installed adjacent to the recess for the lower lock gate and a 14-in. Worthington pump of the same type with a 60-h.-p. motor adjacent to the upper gate recess. The guaranteed capacity of the larger pump is 13,000 gal. per minute against a total lift of 30 ft.; that of the smaller is 5,000 gal. per minute against the same head. Inlets to each pump well are provided from the lock and the nearby lock gate recess, thus making it possible to pump out either recess, stop-planks having been placed across its connection to the lock.

In designing the lock gates three types were considered; the ordinary mitering gate, a gate traveling at right-angles to the axis of the lock, hanging from a rectractile drawbridge, and a gate traveling at right-angles to the lock, but on rails set on the masonry. The first was rejected as requiring too much room lengthwise of the lock, since, owing to the reversal of pressure, a double set of gates at each end of the lock would have been required. The second was considered too cumbersome, so the third type was accordingly selected.

The two lock gates are alike in principle and differ only in detail, so that a description of the larger, or downstream gate, will suffice for both. This gate is higher than the upstream gate, for the reason that the sill is lower and the top higher to keep back high tides. The accompanying illustrations show the construction quite clearly. The frame consists of five vertical plate-girders framing into a horizontal girder at the top and the three middle ones into a horizontal girder at the bottom. The vertical girders carry the total load on the gate, their reactions being taken at the bottom by timber sills set in the masonry, and at the top by the horizontal girder. The loads are brought to the vertical girders by short horizontal girders framed between them as shown. The distance back to back of flange angles on all except the top girder is 5 ft. 11 in., making the thickness out to out of skin plates, which are ½ in. thick, 6 ft.

Under normal conditions the top girder, when loaded, spans the lock and is a beam supported at the ends. It has been considered possible, however, that when one gate is out of commission it would be desirable to open the other, when the tide is at the basin level, to allow a vessel to pass through. Should a delay occur then, a difference of head would result which might cause sufficient friction to prevent the complete closure of the gate and the top girder would then act as a cantilever. To meet this condition the top girder is extended some distance over the rear end of the gate. Four massive adjustable steel castings guide the girder, two with centers 2 ft. 1 in. from the face of the lock wall, one on each side of the gate, and the other two similarly placed at a distance of 19 ft. 10 in. from the lock wall. These take the reactions of the girder when acting as a cantilever. As the position of the gate when acting thus might be almost anywhere on its way across the lock, the design of this girder was most difficult. The girder as it stood on edge in the freight yard is shown in one of the photographs, the underside being toward the photographer.



Lubricator for Lock Gate Truck; and Operating Machinery.

Across the bottom and up on each end, on both faces of the gate are to be fastened 11½ x 14-in. oak timbers, which will bear against corresponding timbers set in the masonry when the gate is in the closed position. These timbers on the gate stop at about the level of low tide and are replaced by cast-iron boxes containing steam coils to prevent the gates sticking by freezing. Further means to prevent freezing will be described below.

Each gate is supported on two four-wheeled trucks, 39 ft. 1 in. center to center, pin-connected to the gate frame. The axles are 7½ in. in diameter and of forged Parsons manganese bronze, this material being practically non-corrosive in salt water and possessing the physical properties of mild steel. The boxes, which are 9 in. long, are of cast iron lined with Parsons white brass. The wheels are of cast iron, chilled and ground on the tread and flange, 30 in. in diameter and weigh 700 lb. each. They were designed and furnished by the Griffin Wheel Co. An interesting test was made on one of them, it being thought desirable to place it under compression and, if possible, to test it to destruction, as under certain conditions it is calculated that the load on one wheel may be as high as 75,000 lb. The wheel was mounted on a 7½-in. diameter steel pin, the same pressure being used for mounting as was used for mounting on the axles. Wheel and pin were placed in a special yoke casting and held against one head of the Emery testing machine at the Massachusetts Institute of Technology. The load was applied at the pin through the yoke. On the other head of the testing machine was placed a short piece of the rail used under the gates (the Cambria crane rail weighing 150 lb. per yard) and the tread of the wheel bore on this. At the limit of the testing machine, 300,000 lb., neither wheel nor rail showed the slightest sign of failure. On slacking off the load a scarcely perceptible depression was found in the rail.

As the trucks will ordinarily run under water, it is possible that no lubrication other than that of the water would be necessary, but the bearing pressures will be so great that it has been thought safer to provide a system of lubrication. The cap on the under side of each bearing is counterbored on the inside, forming an oil reservoir fed through two ⅜-in. holes by a ¾-in. brass pipe extending to the top compartment of the gate, where each has a sight-feed cup and reservoir. A detail of this apparatus is reproduced herewith. The cup is filled with water, the oil rising through it. Air pressure at 7 lb. per square inch is maintained in the reservoir to insure the feeding, as a very heavy oil is used, and also to prevent the water driving the oil back from the bearing at high tide.

To insure ease of inspection of the trucks and rails, the compartment about each truck has been made tight so that the water can be expelled from it by air under pressure making a diving bell of it. Access is then had to it through a small compartment fitted as an air lock.

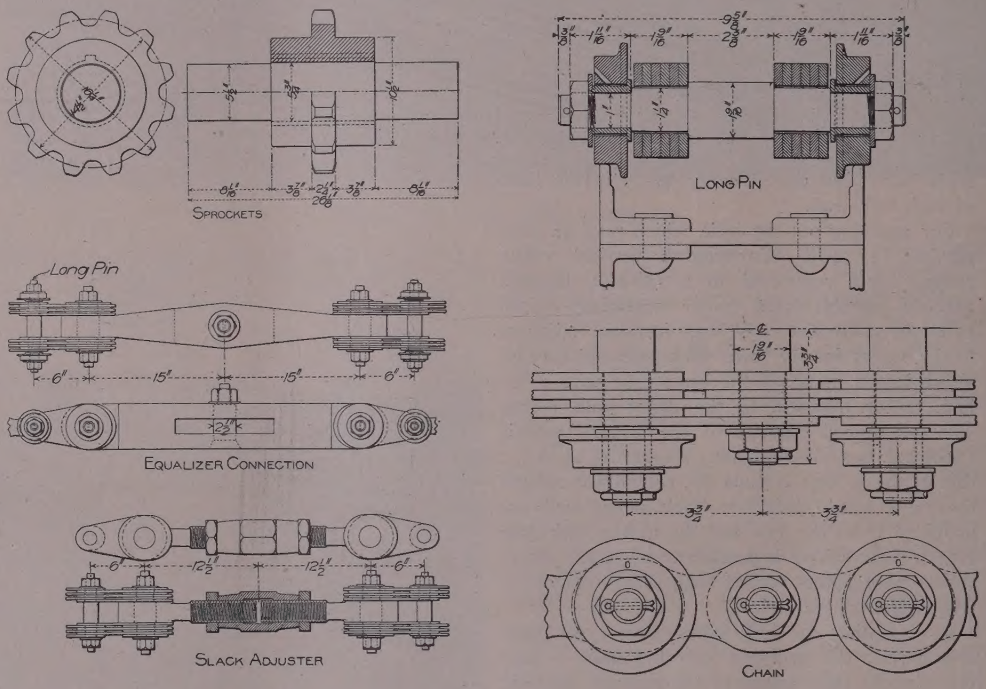
The gates used for filling and emptying the lock, instead of being on conduits by-passing the lock gates, as is usual, are mounted directly on the lock gates themselves. On the lower gate there are six gates 3 ft. 10 in. x 4 ft., giving a total area of 91.8 sq. ft. The upper lock gate has four 3.5 x 4-ft. and three 3.25 x 3.5-ft. gates, giving a total area of 90.2 sq. ft. These sluice gates are of the non-rising stem type, and are built of cast iron, with bronze wedges, stems and mountings. Each gate is equipped with a geared, ball-bearing operating stand, 3-h.-p. Northern waterproof motor and Cutler-Hammer limit switch. The control is such that the sluice gates on each lock gate are thrown in or out to move up or down by a double-throw switch, the group of motors on each gate being in parallel. Should any gate become bound or stuck in operation, it would be automatically cut out by its circuit-breaker, the remaining gates continuing to operate. Each gate is automatically stopped at the wide open or fully closed position by its limit switch, and the switchboard is equipped with indicating lamps to show the position of each. The gates and operating machinery are being furnished under contract by the Coffin Valve Co., of Boston, the Cutler-Hammer Mfg. Co. being subcontractor for the electric controlling devices. These sluice gates may be seen in the photographs of the two gates.

Over each gate recess is to be built a house. That over the upper gate will be a one-story building furnishing protection for the gate operating machinery and the 14-in. pump motor, storage, and support for a 5-ton traveling crane to serve the gate, machinery and pump. The building over the lower recess will contain the 24-in. pump motor, the boiler plant, the administrative offices, quarters for the operating hands and an apartment for the superintendent. On the corner adjacent to the lock and drawbridge will be a tower with four floors, the highest being about 20 ft. above the street level. This top room is to be the general operating and power distribution center. From its windows the entire lock, both lock gates, the drawbridge and the approach to the lock for some distance up and down stream can be seen. The controllers and switchboards for the drawbridge, both lock gates and the lock filling gates, will be located here, as well as the main switchboards for both the 500 and 220-volt circuits, these boards containing the main switches for all auxiliary machinery and all lighting circuits.

A general arrangement of the machinery used for operating the lock gates is given in an accompanying illustration. To the rear end of the top girder of each gate it attached a whiffle-tree, or equalizer beam, each end of which connects by a pin and special forging to the lower run of an endless chain. The operating machine is placed at the rear end of the gate recess and consists of two 50-h.-p. Westinghouse railway-type motors driving a main shaft through three gear reductions. The driving sprockets are mounted on the main shaft.

The chain is of unusual design and deserves special mention. The construction is as shown in one of the illustrations, which also shows the sprockets, means of taking up the slack, and the details of the connections to the gate and to the slack adjuster. The pins and wheels were turned from shafting stock and case hardened, the links are of 40-carbon cold-rolled steel, having an ultimate strength and limit of elasticity of 100,000 lb. per square inch, and the wheel bushings are of phosphor bronze. Each chain travels on a track supported by columns resting on shelves on the walls of the gate recess. The machinery and chains were furnished under contract by the Link-Belt Co., and the erection was by day labor by the Lockwood Manufacturing Co., of Boston, Mass.

The two 50-h.-p. railway type motors which furnish motive power will operate on direct current at 500-600 volts furnished by the Boston Elevated Railway Co. They are arranged for series-parallel control, and in case of necessity either motor may be cut out by throwing a switch in the operating room. The controlling devices are designed to be as nearly "fool-proof" as possible. To move either gate in either direction it will be simply necessary to turn its master-controller handle in that direction. The cutting out of resistance and the changing from series to parallel relationship will be automatically handled by special devices on the contactor board. The master controller is, however, furnished with several notches to allow moving the gate at any desired speed. Should the operator keep the gate at high speed too long, the limit switch, which will be geared to the operating machinery, will cut off all power before the gate becomes fully closed or fully open and it is then possible to finish the operation on the slowest speed only. When fully closed the limit switch again acts and it is not possible then to move the gate farther. Indicating lamps will show the operator the position of the gate at important points. The electric controlling devices are being furnished under contract by the Cutler-Hammer Co.



Details of the Chain on the Lock Gates.

As stated above, the master controllers are located in the operating room in the tower, but for the purpose of moving the gate short distances, as when withdrawn into the recess, a manual controller governing the motors in series only is to be installed close by each gate in the gate room. The change from remote master controller to manual controller will be made by a double-throw switch in the operating room.

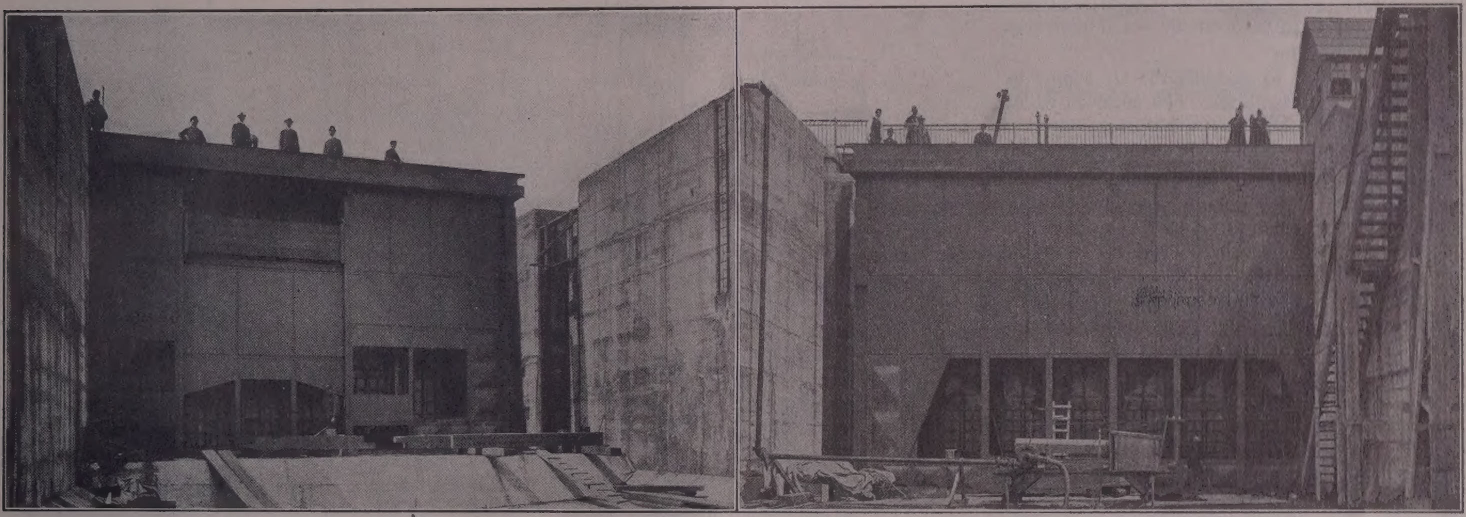
As the act authorizing the construction of the dam requires that the lock be kept "sufficiently clear of obstructions by ice so that any vessel ready to pass through the lock * * * can pass through to the wharves," means for preventing the formation of ice on the lock gates have been provided. To prevent the bearing faces on the gate freezing to those on the masonry the steam-heated castings mentioned above are used. To prevent the formation of ice in the small recess in the lock wall, into which the gate slides when in the closed position, a pocket was left in the concrete between low and high tide which is covered by a steel plate and gasket, in which will be placed two large steam coil radiators close to the plate. The lock gates themselves are similarly warmed by coil radiators in the top compartments close to the skin plates. The available data on the amount of heat required to do this work being practically nil a series of experiments was made to obtain the required information and to determine what method of applying the heat, whether by heating a sheet of water back of or inside the skin plates, by live steam or coils, or by heating the air in the top compartments by radiators, would be most suitable. An account of these tests was given in The Engineering Record of March 16, 1907, in a letter to the editor by Mr. Arthur E. Freeman, who assisted the writer in making them. The results indicated that the use of radiator coils back of the skin plates was feasible and that with this method there would be less chance of supplying a needless amount of heat. The radiators in each gate are supplied with steam from a main pipe running along above the top girder, the connection of which to the pipe from the boiler room will be broken each time before moving the gate and made up again after moving. Sewall steam couplers, such as are used in railway work, and McLaughlin flexible metallic joints, will be used for these connections.

In order to pass ice cakes from the channel above the lock to the harbor the upper lock gate is furnished with an ice-run gate 2 ft. 10 in. high by 13 ft. in length, placed at about basin level. This is on the up-stream face of the lock gate. On the downstream face is a movable timber weir by which the amount of water flowing through the ice-run gate with the ice cakes may be regulated. This weir shows quite clearly in the view of the upper lock gate.

To supply steam to the gates and radiator recesses, and for heating the gate houses and the chambers at the sluices, a boiler plant has been installed consisting of two 48 in. horizontal return-tubular boilers, each with fifty-two 3-in. by 16-ft. tubes designed for 125 lbs. per square inch working pressure, equipped with a Sturtevant steam fan for induced draft. From the boiler room mains run to the sluices, to each lock gate, to the radiator recesses in the lock masonry and to the steam heat system for the lower gate house. The mains to the sluices and radiator recesses pass under the lock through a conduit consisting of 72-in. and 60-in. cast-iron pipe, provided for the purpose; the mains to the upper gate house and to the upper gate radiator recess each pass through a conduit in either lock wall.

Each lock gate is piped throughout for compressed air, which will be supplied by two electrically-driven air compressors having a piston displacement of 50 cu. ft. per minute each. These compressors were furnished by the Westinghouse Traction Brake Co. and are of the familiar street car type, but are water-cooled to allow continuous operation. They are wired in parallel and are automatically cut in when the pressure in the receivers drops to 90 lb. per square inch and cut out when the pressure reaches 100 lb. per square inch, by a Westinghouse Type J governor. This plant is located on the second floor of the operating tower.

As shown in the plan of the dam the drawbridge is adjacent to and just downstream from the lower lock gate. This bridge is of the Scherzer rolling-lift type and was built by the American Bridge Co. There are two leaves, each taking one half of the roadway, which has a width of 85 ft. The track girders on which the leaves roll are on the westerly, or Cambridge side of the lock, so that when open the bridge will not obstruct the view of the operator in the tower room.



Two Views of the Gates for the Lock in the Charles River Dam, Boston.

Each leaf is operated by a 35 h.p. General Electric railway type motor.

On January 25, 1908, a first test was made of the bridge, on April 23 the lower lock gate and on May 11 the upper lock gate were respectively operated for the first time and in every case the operations were entirely successful. The bridge is now practically ready for service and it is expected that the stop planks will be removed from the lock in a few weeks so it will then be opened to traffic, a thing which must be done before the shut-off dam can be completed.

The Charles River Basin Commission is composed of Hon. Henry D. Yerxa, chairman; Hon. Joshua B. Holden and Gen. Edgar R. Champlin. Mr. Hiram A. Miller, M. Am. Soc. C. E., is chief engineer; Mr. Frederick P. Stearns, M. Am. Soc. C. E., consulting engineer; Mr. John L. Howard, M. Am. Soc. C. E., principal assistant engineer; Mr. Edward C. Sherman, Ass. M. Am. Soc. C. E., division engineer in charge of design, and Mr. Arthur I. Plaisted, Assoc. M. A. I. E. E., electrical engineer.

SAND-BLAST CLEANING of the steelwork of the new high-level bridge at Newcastle-upon-Tyne was tried during the erection of the structure and found to cost 4.32 cents per square foot, or three times the cost of hand work. The engineers for the contractors found there were difficulties in working on a large scale, which prevented the method from being used for more than experimental work.

Experiments with Air-Lifts.

During several months of 1907, an extended series of tests were made on a driven well near the plant of The Westinghouse Air Brake Co., at Wilmerding, Pa., to determine the amount of water raised, air required and other conditions relative to pumping by direct air pressure. As many different sizes of pipe and combinations of lift and submergence were tried as were possible, and for each condition the most suitable and economical arrangement of parts was determined. The lift is the vertical distance from the water level in the well to the point at which the water is discharged, and the submergence is the distance from the water level down to the point in the well where air is admitted to the discharge pipe. Since the variety of combinations of these distances and sizes is infinite, a limited number of each were determined upon, which would give enough points on a curve to cover practically the entire range for each size of pipe.

The well used is 174 ft. deep from the surface of the ground, has a 6 in. casing, and the water level is ordinarily from 16 to 20 ft. below the surface. An oil-well derrick was constructed over the well, with platforms at various heights to provide means for altering the lift. The space inside the derrick, below the first platform, was housed in to protect those making the tests and provide suitable space for the tanks and measuring apparatus required. Each length of pipe was measured and marked as it was placed in the discharge pipe, so that an accurate knowledge of the distance to the air inlet and to point of discharge was always at hand. To measure the distance from the ground to the water level, a float was used, consisting of a tin tube about ½ in. in diameter and 4½ ft. long, hermetically sealed, weighted at the bottom, so as to float vertically, and pointed at both ends to assist in its introduction into or removal from the casing. A stout Silver Lake cord was fastened to a ring in the upper end, and brass markers were attached to this cord every 4 ft., each marker stamped with the distance from the water-level point on the float.

The air supply was obtained from a 1-in. connection to the air system of the Westinghouse air brake shops. Two 30½ x 84-in. air storage reservoirs received air from the supply through a three-way cock, so that only one tank could be charged at one time. At the other end of these tanks, connection was made through a similar three-way cock to the line to the well. In this line was placed a 14 x 33 in. reservoir, a globe valve and a cut-out cock. The shop air system averages from 140 to 160 lbs. pressure, to which the storage tanks were charged. Tank 2 was used for measuring the air in the tests, and tank 1 for starting the pumping operation. The volumes of these tanks and their piping were obtained by water measurements. A special test gauge was attached to tank 2. The globe valve in the well line was used to regulate the pressure in the latter. Such pressure was always much less than the storage pressure, and had to be held constant. The cut-out cock was used for cutting off all supply to the well. The small reservoir simply increased the volume of the well line to make it easier to hold its pressure constant.

The special fitting used for admitting air into the discharge pipe consisted of a pipe sleeve enlarged on one side, the upper surface of the enlarged part being drilled and tapped for three air pipes and a 1¼ in. gauge pipe. With the large discharge pipes, there was not room enough inside the casing to get a large air supply pipe, so that two or three smaller sizes were substituted. By this arrangement, also, the effect of changing the sizes of the air supply pipes was easily obtained, since any one of these pipes could be closed at the top by suitable cut-out cocks. The gauge pipe was connected with a test gauge to show the pressure of the air entering the well. The water was always blown out of this pipe when starting the pumping operation. Another test gauge was placed in the air line to the well, so that pressures at top and bottom of air inlet pipe were noted.

The discharge pipe passed up through the roof of the cabin to the point of discharge, at this point the air and water lifted passed into an air separator, the air passing upward to the atmosphere, and the water falling by gravity into one of the two weighing tanks. Just under the roof of the cabin was a large three-way cock, by means of which the water was directed into either one of the tanks and weighed by means of the platform scales upon which they rested.

Nearly eighteen hundred tests were made, covering from 350 to 400 different combinations of discharge pipe, lift and submergence. From the figures obtained in these tests, curves were plotted, showing the variation in the cubic feet of air used per gallon of water raised, and the gallons of water delivered per minute, for the different ratios of lift to submergence. From these curves, it was found that the cubic feet of air used per gallon of water raised and the gallons of water delivered per minute are practically the same for each ratio of lift to submergence, for any submergence of a given size of discharge pipe. For example, a lift of 10 ft. and a submergence of 20 ft. will take the same amount of air per gallon, or lift the same number of gallons per minute, as a lift of 100 ft. and a submergence of 200 ft., the size of the discharge pipe being the same. In both these cases the ratio is identical, while the submergence in the latter is ten times as great as that in the former. Consequently, it is only necessary to consider the ratio of lift to submergence and the size of discharge pipe.

It was also found that, for a given size of discharge pipe, the gallons of water raised per minute decreases as the ratio of lift to submergence increases. Also, the cubic feet of free air per gallon of water raised increases as the ratio increases for a given size of discharge pipe, and for a given ratio, it decreases as the size of discharge pipe increases.

As regards the air pressure required, it was found that the smallest pressure possible that would give a continuous flow from the well was the proper pressure to use. It was found that, if the air pressure was choked down slightly below this point, the water would come out intermittently in spurts, and the aid required per gallon was slightly less than with the continuous flow, but the water delivered was considerably less. On the other hand, if the air pressure was gradually increased above that just required to give a steady flow, the quantity of water delivered would increase somewhat, but the air per gallon increased in a greater proportion, and, as the air pressure was further increased, the gain in the quantity of water delivered grew less, until, at a certain point, it stopped and from then on the water delivered decreased in amount.

It was very easy to regulate the air supply by the sound of the discharge. The point at which the flow became steady was quickly recognized.

From the results obtained, it would appear that for a given lift, the further down in the well the submergence is made, the more economical the result would be. This is true as far as the well is concerned, but it must be considered that the greater the depth of the air inlet, the greater the air pressure must be and consequently the more horse power must be employed to compress the air. The quantity of air required to operate the well decreases as the depth is greater, while the horse power required to compress a cubic foot of air increases with the depth. A curve representing the horse power per gallon of water raised for varying depths and constant lift will at first decrease as the depth increases, until it reaches a minimum point, after which it increases. This point represents the most economical ratio for the given lift. To learn where this point would be, some tables and curves were made which gave the horse power per gallon of water raised for the different lifts and different sizes of pipe, with various ratios of lift and submergence, from which it appears that the most economical ratios for a given discharge pipe decrease as the lift increases, and for a given lift, they increase as the discharge pipe increases.

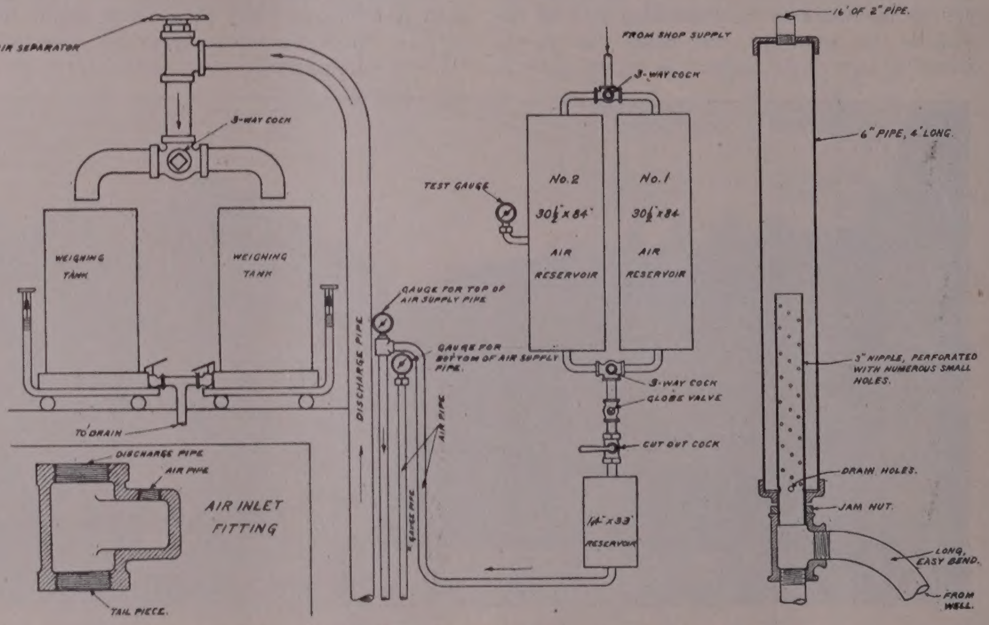
Concerning the use of a tail piece in the discharge pipe below the air inlet, it was found that this piece is essential when starting the pumping operations, as it tends to prevent the air from backing down into the well and rising in the casing, outside of the discharge pipe.

The fitting used for entering the air into the discharge pipe was particularly well adapted to the purpose, because it offered no impediment to the free passage of the water. The results obtained indicate beyond doubt that anything in the shape of a jet or pipe, introduced into the discharge pipe, not only has no value in assisting the pumping operation, but is actually detrimental, by forming an obstacle to the free passage of water. The enlarged sleeve not only offers little resistance to the water, but makes it possible to install the air pipe very close to the discharge pipe.

The size of air pipe depends upon the quantity of air required, its pressure and velocity, and the latter depends upon the difference in pressure between the top and bottom of the air supply pipe, or, in other words, on how many pounds pressure is used to force the air through the pipe.

Taking the results of the tests, and assuming that the drop in pressure is proportional to the length of the air supply pipe, it was found that, for 1 lb. drop per 100 ft., the velocity is about 27 ft. per second; for 2 lb. drop 42 ft. per second and for 3 lb. drop 53 ft. per second. Economical operation is, of course, more easily maintained by having the drop in air pressure as small as possible.

A model was made not long ago of a deep well, having the casing and discharge pipe of glass, for exhibition purposes. The principal loss this apparatus indicates, is probably due to a slip back of a portion of each layer of water past the intervening body of air to the next succeeding layer, caused by the friction of the sides of the discharge pipe. Each change in diameter of the pipe, such as coupling or joints, materially increases this slip, and any obstruction or sudden bend adds to this loss. The bodies of air are not clear but are filled with bubbles and foam, caused by the presence of the water slipping back, but the bodies of water are clear and distinct.



Testing Apparatus, Air Inlet Fitting and Air Separator, for Air-Lift Tests.

In starting the well operation, it is necessary to admit air slowly into the well. The valve should only be opened a small amount, allowing the air to flow slowly and gradually build up to the pressure required. After opening the valve, the pumping will not commence immediately, but several seconds, perhaps even a minute, will elapse before the water discharges, then it comes with a great rush. After this first rush of water there comes a lull for a few seconds, and then the pumping operation begins more uniformly. By opening the valve only a small amount, the air supplied will be a little less than required, and cause an intermittent flow from the well. The valve can then be opened gradually until the flow becomes continuous, which is the proper position in which to leave it.

A New Revetment has been adopted by Major J. F. McIndoe, Corps of Engineers, U. S. A., to protect the levees along the lower Mississippi from erosion by waves due to steamers and high winds. It consists of a slab of 1:5:8 concrete, 4 in. thick, extended from near the top of the levee to its toe and carried down vertically for 2 ft. into the latter. The concrete is reinforced by Clinton wire fabric, laid in strips 4 ft. wide and not overlapped so as to leave planes of weakness, in order that the concrete might adapt itself to any settlement of the banks. This revetment costs twice as much as the plank type heretofore used, but the engineers expect its life to be many times longer.

Deepening a River Channel by Flushing.

The United States Navy Yard at Mare Island, Cal., is about 30 miles from the business center of San Francisco and 35 miles from the Golden Gate entrance to San Francisco Bay. The yard fronts on Napa Creek, a tidal estuary, which is an arm of San Pablo Bay, the latter being in itself part of San Francisco Bay. The channel of this estuary was originally of such depth that it could be used at any stage of the tide by vessels of the largest size. The depth of the channel has been reduced during recent years, however, by deposits of the large amount of sediment that has been brought down in the Sacramento River from hydraulic mining operations in the headwaters of that stream. This sediment consists of finely divided clay that is practically in suspension and moves more or less with the tide until it has been deposited to some depth over the bottom of the bay and various arms of the latter. Napa Creek has particularly suffered from the sediment, which has reached a considerable depth in certain places adjacent to the Navy Yard. Considerable information concerning the rapidity with which this sediment is deposited and the nature of the deposit was given in a description of the construction of the second Mare Island dry dock that was printed in The Engineering Record of April 4, 1908. As a result of the shoaling of the channel, the Government has undertaken quite extensive works to maintain a sufficient depth of water to insure the easy movement of vessels of the largest class in the navy at all stages of the tide. Tight timber bulkheads have been built at right angles to the shore line at various places, in order to confine the channel and to cause the flow and ebb of the tide to scour the latter between the ends of these bulkheads. In addition to the various precautions that have thus been taken, it has been found desirable to devise other means of stirring up and moving the large amount of extremely fine sediment that collects in the channel.

A specially equipped scow has been constructed in the shops of the yard, to be used to deepen the channel by means of flushing. This scow is 70 ft. 7 in. long, has a beam of 34 ft. 7 in. and a depth of 6 ft. 1 in. and is equipped practically the same as an ordinary derrick scow. In fact, when not engaged in the work for which it was built it may be used as a derrick boat. The mechanical equipment is enclosed by a house 28 ft. 10 in. by 45 ft. 6 in. in plan, which is set far enough back from one end to permit a guyed derrick to be erected on that end of the scow. A two-stage, 6-in. turbine pump, with a capacity of 1,000 gal. per minute, is installed in this house. This pump is driven by a 135-h. p. Armington & Sims engine, to which steam is furnished by three 45-h. p. locomotive boilers, fired with crude oil. A double-drum hoisting engine, with two friction drums and four winch heads, is used for handling guy lines on the scow and for operating the guyed derrick. This hoist is supplied with steam from a separate coal-fired boiler; steam to operate the nozzles under the main boilers is first supplied from this hoisting-engine boiler until the former are under sufficient pressure to supply their own steam.

The derrick has a 40-ft. mast, guyed to the deck of the scow with ⅝-in. wire ropes, and a 60-ft. boom. An I-shaped framed boom, with its long axis coincident with the long axis of the scow, is attached to the front end of the latter by two hinged joints, one at each end of the cross-piece of the boom adjacent to the scow. The outer end of the boom is suspended from the boom of the derrick by a block and fall and is thus arranged so it can be raised and lowered. The discharge pipe of the pump connects at the scow end of this framed boom by means of a swivel joint, with a 6-in. coupled wrought-iron pipe that extends out to the other end of the frame and is suspended from the stem of the latter. This pipe connects with a cross pipe, 54½ ft. long, that is in turn suspended from the outer cross-piece of the framed boom. The cross pipe has slots of such size and number as to give the water when forced through these openings the form of a thin sheet, which acts as a cutting edge. The method pursued in dredging is to keep the scow barely in motion, in tow of a tug moving slowly upstream in the ebb-tide and dragging the flushing arrangement astern. By its own weight and the action of the water jet the end of the frame will sink 2 to 4 ft. below the surface of the bottom, depending on the speed, thus stirring up and liquefying the mud sufficiently to permit the latter to be carried out of the channel by the tide.

By a suitable arrangement of valves the discharge of the pumps may be diverted to a manifold connection for four 2½-in. fire streams. The boom at the end of the scow may also be removed and the latter used for general purposes as a derrick scow, since, in addition to the winches of the hoisting engine with which it is equipped, there are hand winches at the opposite end of the scow and numerous cleats, bitts and similar equipment.

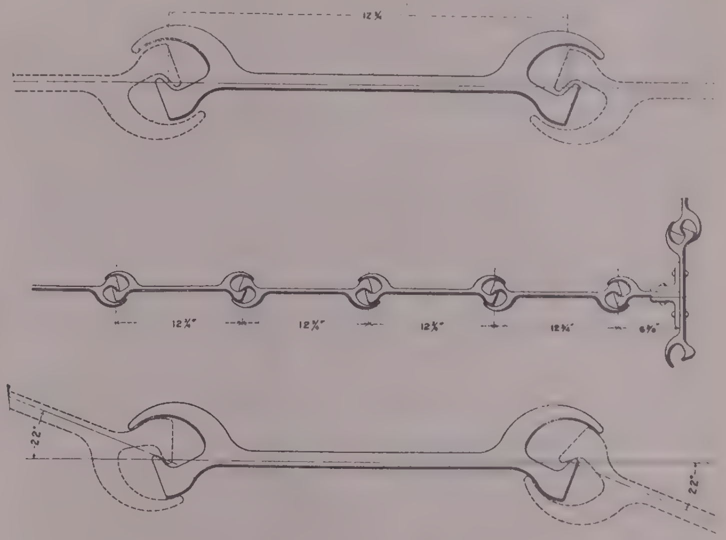
This journal is indebted to Mr. Wm. M. Smith, acting chief of the Bureau of Yards and Docks of the Navy Department, for the information from which these notes have been prepared.

An Extensive Cofferdam of Steel Sheet-Piling.

A ship lock, 114 x 817 ft. in plan, is to be built in connection with the Black Rock harbor and channel improvement that has been undertaken by the United States Government at Buffalo, N. Y. The site of this lock is covered with 3 to 15 ft. of water, with the bed-rock at a depth of 35 to 45 ft. below the surface of the water. As shown by borings made prior to the inception of construction the top of the rock is fairly level, and is overlaid by a stratum of gravel and clay, varying from 2 to 20 ft. thick and containing occasional lenses of hardpan directly over the rock; above the gravel and clay is a stratum of fine sand and gravel that forms the bed of the site. The lock walls are to be all of concrete, built on the bed-rock as a foundation. It is therefore necessary to remove the materials over the rock at the site and to unwater the latter, in order that the concrete work may be handled in the dry.

The contract for the construction of the lock, which has been awarded to MacArthur Brothers Co., of New York and Chicago, includes the provision of a nearly rectangular cofferdam, 260 x 947 ft. in extreme dimensions and covering an area of nearly 6 acres, and 75,000 cu. yd. of concrete masonry. The sides and ends of this unusually large cofferdam are designed to consist of two rows of steel sheet-piling, the rows to be spaced 30 ft. apart and tied together at intervals of 30 ft. by transverse bulkheads of steel sheet-piling, thus forming a continuous series of 30 x 30-ft. compartments, or pockets. The distance between the inner faces of the two sides of the cofferdam is 200 ft., which provides 43 ft. between each of them and the outer limits of the adjacent wall of the lock. About the same space is also secured at the ends of the lock.

Steel Sheet-Piling Driven for Portion of Cofferdam.



Details of Steel Sheet Piling Adopted.

The rock inside the cofferdam is to be stripped, except that a shoulder will be left against the steel sheeting entirely around the inside of the cofferdam. This shoulder will have a minimum depth of 20 ft. against the sheeting and with such slope on the surface as the materials will take. The materials inside the pockets of the cofferdam will not be disturbed and the pockets will be filled with clay from the natural bottom level to above the water surface.

Under these conditions, with the cofferdam unwatered, it is believed that the only pressures to be expected will result from the filling in the pockets reacting against the rows of piling forming the inner walls of the sides and ends of the cofferdam. Consequently, the transverse bulkheads of sheet piling will receive the principal stresses on the latter and these stresses will be in tension. It was therefore desirable to select a section best adapted to meet this requirement of large tension stresses.

The contractor accordingly decided to purchase first a sufficient quantity of each of several standard sections of steel sheet-piling to build one of the pockets of the cofferdam, as a field test under the working conditions to be met. The various sections were also subjected to other tests to determine the one that could be used most satisfactorily in the work in hand. The various tests have recently been concluded and the contract for the steel piling has been awarded to the Lackawanna Steel Co., of New York and Buffalo, for the rolled Lackawanna section of that company. This contract includes a total of 7,000 tons of steel piling, making it by far the largest of the kind that has ever been awarded.

The results obtained with the successful section are of more than ordinary interest since they were conducted in an entirely disinterested manner by the contractor, according to the methods best adapted to each type. The piles were in 45 and 50-ft. lengths and were driven with a No. 2 Vulcan steam hammer working in 60-ft. leads mounted on a pile-driver scow. Careful records were made of the number of blows required to drive each pile and the total penetration of each of them. From the average of the total number of linear feet of penetration reached by each type of piling tested and the total number of blows required to secure this penetration, the average number of blows per linear foot of penetration was deduced. This average was 14.91 blows in the case of the Lackawanna section, which was only slightly different for the other rolled section driven and was considerably less than for the fabricated sections.

A number of tests of the different types of piling acting in tension were also made to determine the strength of the various methods of securing an interlocking joint. The average of several tests made on the adopted section showed the lock of the latter to stand 9,700 lb. per linear inch of direct tension with a combination of two pieces. This value is higher than was obtained with any of the other sections tested, and as it is one of the chief features of strength required in the piling used in the construction of this cofferdam, it was particularly favorable to the selection of the adopted section. Other conditions specially favorable to this section were also effective in determining the selection.

The details of the adopted section are shown in an accompanying drawing, while the appearance of a considerable tonnage of the piling driven in place is given in a second illustration. Although the details of the section are evident from the drawing, attention should be called to what are considered the features of this new type of steel sheet-piling. The sections are entirely integral and require no fabrication or assembly, since they are interlocked by means of a special lock on each side, that is part of the rolled section. Each section is also a duplicate of every other, and as both ends of the section are exactly alike, the latter is perfectly balanced, giving it uniform strength throughout. The lock, the detail of which is shown, provides three points of bearing in every joint which, together with the material that is crowded into the space in the lock during driving, produces a practically watertight joint. The locks, at the same time, form a joint such that a maximum angle of 22 deg. may be obtained between adjacent sections, thus permitting a wall of piling to be driven to a radius of 34.5 in. Sharper angles in a row of the piling are obtained by cutting a section in half longitudinally and riveting the web of the half section to the web of the section at the junction by means of structural angles.

The steel piling was driven under the immediate direction of Mr. N. J. Beisel, superintendent, and the supervision of Mr. W. G. Sloan, Eastern manager of the MacArthur Brothers Co., who will also direct the completion of the cofferdam and the construction of the lock.

The Operation of a 16-Inch Water-Main Siphon.

Richmond, Ind., a city of about 21,000 population, is at the intersection of three branches of the Whitewater River, these branches being supplied ordinarily by springs, with a rapid run-off in times of heavy rainfall. The geological formation in the vicinity consists of strata of limestone overlaid with gravel and clay, and is such that deep wells are not available. On the other hand, the use of the three branch streams for a storage supply is not advisable. A pumping station on one branch of the river, 2½ miles from the city delivers to a 10,000,000-gal. reservoir a mile distant and 180 ft. above it, the present average daily pumpage being 2,000,000 gal. In 1896 it was found necessary to secure an additional supply, which was done by means of a 16-in. siphon line, 3 miles in length, and extending into a different watershed. The shorter leg of this siphon has a very low grade, making a gravity line practically impossible. The operation of this siphon was described before the American Waterworks Association in a paper presented by Mr. Howard A. Dill, from which the following notes are taken.

Heretofore the air in this siphon has accumulated at the summit of the 16-in. pipe, gradually reducing the flow. The watershed that is tapped has an area of about 2½ square miles, with a very deep under layer of porous gravel, lying 1 to 2 ft. below the subsoil of black loam. A brick well, 18 ft. in diameter and 14 ft. in depth was constructed near the center of this watershed, with about twenty pipes 2 in. in diameter, driven 10 to 15 ft. into the gravel below and extending from the bottom of the well. Two traction engines and two 6-in. centrifugal pumps were required during the thirty days of its construction.

The 16-in. pipe is laid close to the bottom of the supply well, and the water flows into an outer well at the pumping station, having a diameter at the bottom of 11 ft. 2 in. and a depth of 9 ft. A check valve is placed at the supply well, and at the highest point of the siphon there is a vertical check valve connected to the 16-in. pipe by a 6 x 16-in. tee and a 3 x 6-in. reducer. This check valve is of special construction, being 10 in. in diameter, weighted with 30 lb. of lead, and has a 3-in. outlet. At the pumping station, the siphon is connected with the reservoir line by a 6-in. pipe. The elevation of the reservoir at normal stage is 1140.1, that of the crown of the siphon is 1057.27, and that of the average water level at the siphon well is 1053.82. A gauge at the pumping station registers the pressure in the siphon line. To fill the siphon, the 6-in. connection with the reservoir was opened, and the air forced out through the check valve at the summit, giving a pressure of 40 lb. on the gauge when the siphon was filled. The flow of the siphon is regulated at the pumping station by a 16-in. valve, with same opened usually from eleven to twelve turns out of a total of fifty-two turns.

To test the flow of the siphon, the line was filled very slowly from the reservoir, after which the gauge registered 40 lb., and the 16-in. valve was opened eleven turns. The well into which the siphon empties connects with the suction well of the pumps by a 24-in. pipe, with the spigot end projecting into the outer well. By means of a wooden plug, operated by a lever, and lined at the outer edge with rubber hose, the flow into the inner well was stopped. A rise of 2 ft. was measured by a float, and the time in seconds secured by a stop watch. The rate of flow for 24 hr. for each pound of gauge pressure was thus obtained, the test lasting 144 hr. From these results it was found the flow varied from about 490,000 gal. with 6 lb. to nearly 910,000 gal. with 37 lb. The time required to fill the siphon varies from one-half hour to two hours, the efficiency of the filling depending upon the speed at which this is done. If filled too rapidly the air in the siphon mixes with the water, and the subsequent flow is reduced. During periods of heavy draft, it has been necessary to fill the line twice a day, with the regulating valve open twelve turns. It has also been found that a wider opening of the regulating valve, while giving an increased flow, causes the air to accumulate at the summit so rapidly that the total discharge in 24 hr. is increased but little over that given with a slower discharge.

In 1904, Mr. John W. Alvord investigated the possibilities of this and other sources of supply, and his report recommended the development of the watershed now tapped by the siphon. After some preliminary tests on the volume of air accumulated, Mr. Dill recently installed equipment to remove the accumulated air. At the summit a building 18 x 21 ft. in plan and 10 ft. high has been erected. To make this building frost-proof, the walls were constructed with a cross section of two thicknesses of ship lap, one of weather boarding, two of heavy building paper and 6 in. of sawdust. The machinery consists of a 40-in. by 12-ft. horizontal boiler, supported on two concrete piers, and placed directly above and connected with the 3 x 6-in. reducer and 6 x 16-in tee already mentioned. A 6 x 6-in. horizontal Clayton air compressor, connected by a noiseless link chain with a 2-h.-p. General Electric motor, is located near this boiler. The compressor has a 1.5-in. outlet and a 2-in. inlet; its rated speed is 150 r.p.m.. its discharge capacity is 29.5 cu. ft. per minute. The motor is shunt wound, and is rated at 800 r.p.m. A Halls-Canna lubricating pump is attached to the compressor to feed all bearings and the cylinder. On the inside of the boiler is a 10-in. copper float attached to a 3-ft. lever, to which is also fastened a ⅜-in. brass rod. This rod consists of two parts, one end being secured to the lever arm, the other passing through a stuffing-box at the top of the boiler, the two parts being connected by a hinge having a vertical and horizontal motion. The upper rod is fastened to a chain passing to a lever switch. This switch operates an automatic electric starting device, consisting of a solenoid current breaker and a rheostat. By this device the power supply for the 2-h.-p. motor, which supply consists of 500-volt direct current obtained from the Dayton & Western Traction Co., is switched on and off.

When the siphon line and boiler are filled with water, the float throws the lever switch and the current is cut out. As the air in the siphon gradually passes into the boiler, this float lowers with the water level, until the switch throws on the current, and the compressor again exhausts the air in the boiler. To avoid the possibility of the float not throwing off the current, thereby causing the water to be drawn into the compressor, the 2-in. outlet pipe was extended from the top of the boiler to a height of about 40 ft. from the water level in the supply well of the siphon, and thence run downward to the inlet of the compressor. Ordinarily this arrangement would have been satisfactory, but soon after the apparatus was started the float failed to operate, and water entered the compressor. In Mr. Dill's opinion, this trouble was caused by the heavy volumes of air passing into the boiler from the siphon line, thence into the 2-in. outlet pipe, lifting a column of water equal to the volume of air discharged. To prevent a repetition of this, a float valve was placed at the entrance of the outlet pipe of the boiler, which will close the opening when the water level reaches this stage. To permit the filling of the siphon from the reservoir, a tee was placed in the pipe connecting the siphon and the boiler, and the special check valve set on this branch. By means of valves on both connections, the air in the siphon can be removed by the compressor or by the reservoir.

After the test to which reference has been made the siphon was shut off at the pumping station on May 20, at 6 a. m., the pressure gauge registering 6 lb., and the rate of flow being 484,000 gal. for 24 hr. At 7:30 a. m. the air pump was started, with the vacuum gauge showing 2 in., and operated for 7 hr. and 10 min. actual running time during that day and the one following, at the end of which the air was exhausted from the siphon and boiler; the vacuum gauge then registered 16 in. and the pressure gauge at the pumping station 40 lb. The amount of current consumed was 6.3 kw., which cost 8 cents per kilowatt, making the total power charge 50.4 cents. The compressor theoretically discharged 9,862 cu. ft. of air during this time, involving a cost of 5.11 cents per 1,000 cu. ft. of air discharged. The following day, with the conditions the same as at the close of the test, the pump at the station was started with the 16-in. valve at the latter opened eleven turns and the gauge indicating 40 lb. pressure. During 9.5 hr. the siphon discharged 433,413 gal., equal to a rate of 1,075,000 gal, per 24 hr., and the compressor exhausted 1,233.67 cu. ft. of air with a power consumption of 0.9 kw., costing 7.2 cents. The cost of the current per million gallons of water was therefore 16.92 cents, and per 1,000 cu. ft. of air, 5.84 cents, while the cubic feet of air discharged per million gallons was 2899.2.

This apparatus has been in operation about one year, and is proving satisfactory. As the lead joints in the pipe line become tighter, it is believed still better results will be secured.

A Portable Blacksmith Shop has been found very convenient and economical in the maintenance of way department of the Missouri Pacific. It consists of two box cars, one for sleeping accommodations of the blacksmith and his helper, and the other for the shop. All necessary tools and duplicate parts are carried for repairing switches, frogs, hand cars, switch stands and similar railroad appurtenances. Frogs are taken from the track, repaired and replaced where traffic is light, by protecting the point by flags, and where traffic is heavy, a duplicate frog is put in. The portable shop saves shipping the tools and equipment needing repairs, thus reducing cost and avoiding delay. It has been found that one day, according to the "Railroad Gazette," is sufficient for cleaning up the repairs on an ordinary section.

Progress on the Ashokan Reservoir.

The Ashokan Reservoir near Brown Station in the Catskill Mountains, Ulster County, N. Y., about 100 miles from City Hall in New York City, is a part of the extensive system of works under construction to secure an additional water supply for that city. It is estimated that the entire system, which has been designed and is now under construction by the Board of Water Supply of the city of New York, will provide 500,000,000 gal. of water daily, and, according to preliminary estimates, will cost $162,000,000. The water will be collected in the Ashokan impounding reservoir of 120,000,000-gal. capacity, which will receive the waters of Esopus, Beaver Kill, Schoharie and Catskill Creeks and other small watersheds.

The reservoir will be formed by the construction of masonry and earth dams across Esopus Creek, 14 miles west of the Hudson River at Kingston, and across the Beaver Kill Creek and low parts of the valley at adjacent points. The reservoir will be about 12 miles long and 1 mile wide with an area of about 12½ sq. miles at the flow line at an elevation of 590 ft. above sea-level, the water having a maximum depth of about 190 ft. The aggregate length of the different dams for this reservoir will be about 3.8 miles. The construction of these dams and of the auxiliary work included in the general contract for the reservoir will include about 2,055,000 cu. yd. of earth excavation, 425,000 cu. yd. of rock excavation, 880,000 cu. yd. of concrete of all descriptions and 7,360,000 cu. yd. of earth and rock embankment of all classes. The contract price for the reservoir, based on the unit prices for the estimated quantities, is about $12,660,000.

Esopus Creek and Site of South Wing of Olive Bridge Dam.

The principal items of construction work for the reservoir are the Olive Bridge Dam, the Beaver Kill dikes, the waste weir, the dividing weir, the gate chamber, two aqueducts and two inlet chambers, all located as indicated on the accompanying general plan.

The most impressive single structure is the Olive Bridge Dam, which has a concrete masonry part about 1,000 ft. long, 190 ft. wide at the base and with a probable extreme height of about 240 ft. from crest to bottom of cut-off wall. At each end there is an earth embankment wing with a concrete core wall extending the length of the dam to a total of about 4,800 ft. The Beaver Kill Valley will be crossed by the West Dike, the Middle Dike and the East Dike, all of earth embankment with concrete core walls and a maximum height of about 110 ft. above the present surface of the ground. Their total length will be about 2.3 miles, and the wide base and flat slope will be of special construction with unusual provision for water tightness and protection.

The waste weir at the east end of the East Dike will be a masonry structure about 1,000 ft. long and 6 ft. high above the surface of the rock as excavated. The dividing weir will separate the reservoir into East and West Basins of 82 billion gal. and 48 billion gal. capacity, respectively, the former receiving the waters from Esopus Creek and the latter from Beaver Kill. The north portion of the weir, about 1,100 ft. long and 25 ft. in height above the surface of the rock as excavated, will be built of masonry and will provide an overflow for passing flood water from the west to the east basin en route to the waste weir. The south portion will be of about equal length, with a top elevation 20 ft. higher, and will be constructed with earth embankment, perhaps containing a core wall.

The gate chamber, located in the dike portion of the dividing weir, will be an elaborate concrete structure providing for the control of the water supply from the reservoir and connecting the aqueducts and the inlet channels. The two aqueducts, about 610 ft. long, will be built of concrete, one above the other in the same trench, and will extend from the gate house under the dividing weir and middle dike to a lower gate house not included in this contract. The east inlet channel, about 3,000 ft. long and 80 ft. in maximum depth, will be excavated in open cut, chiefly in rock in the bottom of the east basin, to connect the deepest portion of it with the gate house. The west inlet channel, about 5,800 ft. long and with a maximum depth of 80 ft., will be excavated chiefly in earth in the bottom of the west basin to connect its deepest part with the gate house. The average depth of both channels will be about 40 ft. and the bottom width about 26 ft. in rock and 38 ft. in earth.

The contract drawings and specifications for this work were prepared with unusual skill and care and were issued in two volumes, one containing 174 pages of printed matter, including careful descriptions of the work and minute explanations, and the other containing 57 large folded sheets showing the plans, maps, elevations, sections and principal details of all the construction.

The engineering department of the Board of Water Supply established a very large and efficient organization, conducted extensive preparations and investigations at the site and has organized a competent force to supervise the construction. This department made hundreds of miles of topographic and property surveys, and numerous test holes and pits indicating the character of the soil and rock and the probable conditions to be encountered in the foundation, and provided a vast amount of preliminary information for the official estimate which was available for bidders, and was found to be so unusually thorough and valuable that in some cases the bidders accepted it and made their bids with only the briefest inspection at the site. The successful bidder, however, spent several weeks with a corps of assistants in preliminary examinations and investigations of the conditions to be met.

The present population of the five boroughs of New York City approximates 4,300,000 and requires a supply of 500,000,000 gal. per diem, for which there will be available in 1910, when the present Croton system is completely developed, an estimated supply of only 325,000,000 gal. daily. It is estimated that in 1915 a supply of 710,000,000 gal. will be required for the increased population, and in 1930 a supply of 1,000,000,000 gal. will be required. It is therefore evident that the construction of the Catskill system is an emergency work, so it was designed and the provisions for its execution have been made with a view to securing great rapidity in building the different portions of it and in enabling it to be put in partial service at the earliest possible date.

It is the special purpose of the Board of Water Supply to hasten the construction of this reservoir so that the West, or Esopus Basin, will be ready to store and supply a considerable quantity of water within 54 months after the commencement of the work. To this end, it is particularly specified that the contractor shall furnish a large amount of special plant suited to rapid and efficient construction, and many of the principal items including cableways, concrete machinery, power plant and important tools are enumerated, and provision is made for the duplication of essential parts of important machinery. Besides the usual restrictions and directions intended to promote the most satisfactory execution of the work and prevent any danger or damage to the owners or employees, it is particularly specified that:

"Sanitary conveniences for the use of all persons employed on the work shall be constructed and maintained by the contractor in sufficient number in such manner and at such places as shall be approved. All persons connected with the work shall be obliged to use these conveniences. The sanitary shall be connected with one or more disposal plants, while all sewage shall be treated so as to yield a reasonably clear and colorless effluent, free from disagreeable odors. Samples of the effluent shall show no increase in the oxygen consumed after being kept 3 days at a temperature of 80 deg. Fahr. In addition to the above, pan closets shall be provided and properly cared for at convenient points on the parts of the work remote from the disposal plants, wherever necessary for the prevention of nuisances.

"Garbage, both liquid and solid, shall be promptly removed from the buildings and immediately placed in approved tight receptacles of sufficient capacity for about one day's ordinary production. At least once in 24 hours all such garbage shall be incinerated or otherwise thoroughly satisfactorily disposed of so as not to create a nuisance.

"The contractor shall provide medical and surgical practitioners to give attendance and medicines to the employees whenever needed, and to inspect the dwellings, sanitaries and stables at least once a week. He shall also provide and equip a hospital for the care of sick and injured employees."

The general clauses of the contract provided that work should first be commenced on the Olive Bridge Dam, then on the Beaver Kill Diversion and the core wall excavation for the middle dike, and that within nine months masonry construction should be commenced in the Esopus Gorge in the core wall of the north wing of the dam, and at the middle dike crossing at Beaver Kill with sufficient force and equipment for its effective prosecution and the commencement of the work on the other weirs and dikes, quarries, sand pits and borrow pits shall be early developed on a scale to insure the abundant provision of material.

Within eighteen months the force and equipment must be adequate to prosecute all of the contract work with sufficient rapidity to comply with the schedule of progress and to complete the Olive Bridge Dam, West Dike, dividing weir, pressure aqueducts and gate chambers to at least Elevation 520, and to complete the west inlet channel ready for impounding water in the west basin and delivering it through the pressure aqueduct within the 54 consecutive calendar months next following the date on which notice was served by the Board to begin work.

It is especially emphasized in the contract that the time in which the various portions of the work is to be executed is the essence of the agreement, and the schedule carefully prepared to allow for the installation of the plant, and the preliminary and auxiliary construction requires that in nine months ofter the service of notice to begin work at least 2 per cent. of the total, estimated on the statement of quantities and contract prices, shall have been completed; in 16 months, 9 per cent; in 28 months, 23 per cent.; in 40 months, 41 per cent.; in 52 months, 61 per cent.; in 64 months, 80 per cent; in 76 months, 96 per cent., and in 84 months, 100 per cent.

At the dam site the Esopus Creek flows through a rock channel, about 200 ft. wide and 40 ft. deep, with nearly perpendicular sides and a horizontal bottom. The creek drains a watershed of about 240 sq. miles above the dam, from which there is a flow at the dam varying from 100 cu. ft. per second in dry season to 38,000 cu, ft., or more, in time of flood and likely to attain 15,000 cu. ft. per second every year. The contractor is required to provide against any damage from these waters during the construction of the work, and especially to maintain for some time the flow of the Creek so as to prevent interruption of a water supply to the Eastern Dynamite Company, located about 1½ miles down-stream.

In their investigation of the site the Board had constructed on each side of the base of the dam a cofferdam across the channel of the Esopus Creek, which dams have since been turned over to the contractors and will help to exclude the water from the foundations during construction. The cofferdams are rock-filled timber-crib structures about 20 ft. wide, with sheeted sides and clay embankment, and were so tight that the water between them was removed by a Brooks centrifugal pump with 12-in. suction and 10-in. discharge, direct-connected to a Sturtevant engine. At one end of each cofferdam there was built a concrete pier about 25 ft. wide, 6 ft. high and 45 ft. long; to these piers are anchored a pair of 8-ft. riveted-steel pipes to carry the dry weather flow of the creek.

North End of Cut for Masonry Section of Olive Bridge Dam.

During the construction of the dam masonry, it is intended to maintain a depression around these pipes until the upper part of the masonry is carried to a higher level, thus affording an outlet for flood water, which may overflow the cofferdam and submerge a portion of the work without injury until the steel pipes are removed, a conduit tunnel built through the dam adjacent to them at about the same level and the masonry filled in solid over the original position of the pipes. The tunnel conduit will thus provide an ample bypass for the water and permit the uninterrupted construction of the dam masonry until it is closed with permanent masonry and the impounding of water in the reservoir is commenced. These cofferdams have remained intact through a winter of severe high water, and the contractor is now placing additional clay puddle against the upstream side of the lower crib as an added precaution against leakage.

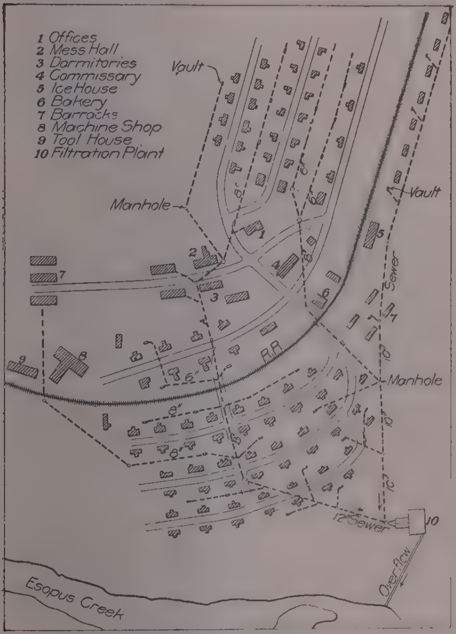
The Beaver Kill watershed above the middle dike has an area of about 17 sq. miles and an estimated flow of about 2,500 cu. ft. per second in times of flood. It is proposed to divert the stream by means of a temporary dam, about 210 ft. long and 12 ft. high, and a by-pass channel about 1,200 ft. long temporarily delivering the flow of the creek to the lower portion of its channel until the works have progressed to such a stage that the diversion channel is closed by an earth dam and the construction of the works is completed. The diversion cofferdam will be an earth and rock embankment with a core made with two lines of sheet piling and puddle fill.

The contract was advertised and bids were invited July 2, 1907; bids were opened August 6, the contract was awarded August 31 to MacArthur Bros. Co. and Winston & Co., who have large experience in similar work, including the great Wachusett Reservoir for the Boston Water Works and the emergency work for the Cross River dam at Katonah, just completed successfully for the Croton Aqueduct Commission, New York. These contractors had a large force thoroughly organized and a very extensive equipment of plant, tools and power ready for immediate installation, and as their bids corresponded closely with the engineers' estimate and confidence was felt in their ability and disposition to execute the work rapidly and satisfactorily, the contract was awarded to them at a considerably higher price than was bid by one of their competitors. A considerable delay resulted from an investigation, to which reference has been made in detail in this journal, before matters were adjusted, so that formal notice to the contractors to commence operation was not given until Feb. 20, 1908.

The result of this delay would have been to impede the preparation so much that it would have been impossible for effective operations to be commenced during the present season, if the contractor had not had the courage and determination to commence the work without authorization, in the belief that the contract would be supported and perfected. This was accordingly done and without waiting for a formal notice the contractor immediately commenced vigorous operations and carried on preliminary work during the winter, so successfully that when the spring opened all was in readiness to commence the installation of the plant and to begin excavation, thus providing for a large amount of effective work, which would otherwise have been impossible, and correspondingly promoting the timely completion of the work.

The first work done by the contractor was the construction of a branch line of standard-gage railroad track, about 1 mile long, from the Brown Station of the Ulster & Delaware R. R., to the camp and the site of the Olive Bridge Dam. Simultaneously with this work the massive concrete foundations were built for the compressor engines, large store houses and office buildings were erected, a machine shop was built and fully equipped, a line about 3 miles long was located to the quarry, plans and estimates were made for the structures required for it, and general surveys were vigorously prosecuted during the winter, and plant and materials were delivered as rapidly as possible after the completion of the railroad, thus enabling general operations to be commenced as soon as the weather permitted. A large proportion of this work was done and many thousand dollars were expended during the uncertain period of litigation before orders to commence were received, and involved a considerable risk of ultimate payment which was assumed by the contractor to expedite and benefit the work.

The principal equipment for the execution of this work, already partly installed, includes four great cableways and a derrick system for the Olive Bridge Dam, a stone quarry and several sand pits, a large amount of excavating and transporting plant for the construction of cuts and filled work, rollers for compacting the embankment, derricks, steam shovels, pumps and other standard machinery, a large power plant and distribution service, two systems of water supply and distribution, a sewage-disposal system, an extensive system of railroad service, wagons and new equipment, a large plant for stone crushing and sand elevating, conveying, storing and delivering plant, a concrete mixing plant with a nominal capacity of 1,200 cu. yd. per diem, concrete conveying and handling apparatus and a block yard with molds and facilities for casting and handling 200 cu. yd. of concrete daily for face work, and a camp organization with sanitary provisions and other improvements on a large and expensive scale calculated for the safety, comfort and welfare for a great body of men for several years, and equal or superior in many respects to excellent municipal systems.

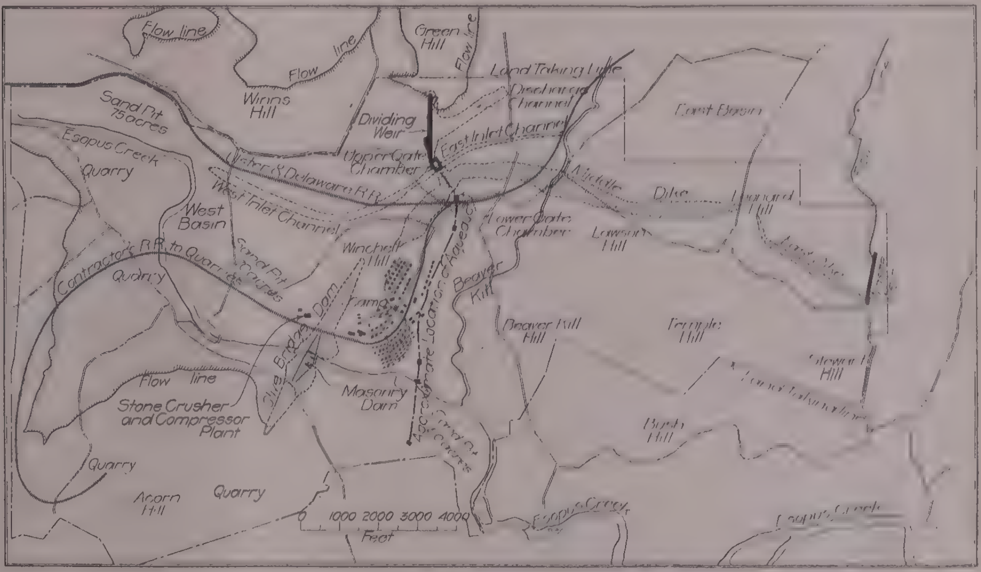


Plan of Camp.

Nearly all of the plant and temporary construction is installed on a scale far larger than would ordinarily be considered requisite for work of this magnitude, in order to provide not only for the severe progress requirements of the official schedule, but to secure the highest quality and greatest rapidity in the work that it is possible irrespective of the contract specifications. Many hundreds of thousands of dollars' worth of plant have been and will be installed, a large quantity being of special design or construction intended for this particular work and in many cases chargeable exclusively to this contract.

The Olive Bridge Dam will contain about 500,000 cu. yd. of mass concrete, 64,000 cu. yd. of concrete blocks, 60,000 cu. yd. of concrete core wall and 1,900,000 cu. yd. of earth and stone embankment. It has a cross-section of the same general type as the new Croton Dam, the Wachusett Dam and the Cross River Dam. Its construction corresponds substantially to that of the Cross River Dam, with the exception of some special features, including an inspection gallery and the provision for the collection and drainage of any seepage water that may possibly be found in the finished structure. Its construction and that of the typical dikes, with special protection and drainage features, were illustrated in a preliminary outline of the work containing a general location map published in The Engineering Record of May 11, 1907.

Work on the Olive Bridge Dam has been commenced by completing cofferdam built by the Board of Water Supply, stripping the surface and excavating for the main foundation and preparing the surface to receive the earth embankment. Four 1,534-ft., 15-ton Lidgerwood cableways, together with a row of powerful stiff-leg derricks will be installed parallel with the axis of the dam to handle all materials of excavation and construction and two of the 90-ft. timber head-towers and one 90-ft. tail tower for the cableways, have already been erected and one of them is in service with a small temporary cable and special carriage, and fixed shear legs for a tail tower operating a special carriage to facilitate the preliminary work until the completion of the main cables. The ground has been leveled on both sides of the creek to provide for the head and tail-tower tracks at elevation of 546 ft. These tracks are 107.5 ft. wide over all and their length of 700 ft. enables the cableway service to command a large area of work. The cableways will have hoisting and traversing speeds of 1,200 ft. per minute and the towers will be moved back and forth by separate and independent small hoisting engines operating anchored lines.



Location of Dam, Dikes and Inlet Channels.

The cableways and all other hoisting engines, pumps and, in general, all machinery, except the steam shovels, locomotives and remotely detached plant, will be operated by compressed air. The head towers of the cableway, each containing about 60,000 ft. of first quality pine timber from 12 x 12-in. down, were assembled with one face on the level surface of the ground and afterward revolved bodily into position around one lower sill firmly secured to the trucks specially anchored in position for this purpose. After being assembled on the ground the erection of each tower was easily and successfully accomplished in about 20 minutes by the aid of the cableway hoisting engine operating two 6-part tackles led over a shear frame about 55 ft. high to provide for the initial elevation of the hoisting lines.

The foundations for the masonry part of the structure have been very thoroughly explored by a series of 15 Diamond drill borings to a minimum depth of Elevation 305, about 100 ft. below the present bed of the creek. A very careful study of the cores and records of the borings was made and each hole was thoroughly tested by a special apparatus to determine positively the permeability of all portions of its length, thus giving a remarkably reliable information concerning the underlying rock, the location of seams and the probability of seepage or flow through them. From these indications it is supposed that the general excavation will not require it be more than about 10 ft. below the surface except in the case of the cut-off wall. The usual and some additional precautions are taken to avoid any unnecessary disturbance of the existing rock; heavy blasting is not permitted and the sides are being cut smooth by Sullivan channelers making a slot 4 in. wide on top and 10 ft. deep. The earth is very compact and before removal is shattered with dynamite, after which it is excavated with pick and shovel and at present is being loaded by hand on wagons and hauled about 300 ft. and deposited without rehandling to form the fill for the embankment portion of the dam.

A heavy layer of rip-rap for protection and drainage is built on the outer faces of the slope and the earth, carefully selected and approved, is deposited in layers of not more than 6 in. on downstream and 4 in. on upstream side, moistened, leveled and thoroughly compacted with steam rollers manufactured by the Monarch Road Roller Co., Croton, N. Y. It is required that the weight and proportions of the rollers shall be such that with a penetration of 1 in. the rear wheel shall have a pressure of 30 lb. per square inch on an area of the cylindrical surface having a middle ordinate of 1 in. So far this pressure has been considerably exceeded, but on account of the character of the soil, considerable difficulty is experienced in operating the rollers in wet weather and some improvements are now being made which will greatly increase the traction power and still maintain the effective pressure at about 34 lb. per square inch.

As all of the embankments have core walls and require the construction of extensive drainage ditches, besides the clearing, stripping and some excavation of the entire area, considerable time and expense is requisite for the preparatory work, before embankments can be commenced. Care and forethought has been expended by the contractors on the co-ordination of the work, and on arrangement and synchronism to provide as far as possible for the most efficient and advantageous combination of the different portions of the construction, so the excavated material when acceptable may be advantageously transferred without rehandling from cut to fill and deposited permanently there in a manner to give the greatest rapidity and most desirable construction. In some of the dikes where the core wall is likely to extend to a great depth it may be difficult, or impossible to provide for the construction of the embankment as soon as the earth most adaptable for it is excavated. But in other places less difficulty will be found and the great width of the embankment will allow the disposition of a large quantity of material at a low elevation.

A force of about 400 men is now at work on the foundations of the Olive Bridge Dam for which a portion of the excavation has already been carried to the surface of the rock. About 300 men are busy on the middle dike, across the Beaver Kill, where stripping and excavation for the core wall is in progress, with hand and team labor.

Another force of about 200 men and one steam shovel is grading for the standard-gauge quarry track, which approximately follows the contour up the side of the valley to a point about 1 mile above the Olive Bridge Dam, where it will cross Esopus Creek on a viaduct 1,200 ft. long and 80 ft. in maximum height, including 390 ft. of steel construction with 30-ft. towers and 60-ft. plate girder spans, which will be fabricated and erected by the American Bridge Co. The track on the viaduct is at Elevation 525, and from this point it rises with a maximum grade of 2½ per cent. to the quarry at Elevation 740 and in the opposite direction has a 1 per cent. maximum grade for the loaded cars.

Site of Earth Wing at North End of Olive Bridge Dam.

The quarry is an outcropping of bluish-gray sandstone of the Hamilton flags formation and the stone is stratified in approximately horizontal layers up to 3 or 4 ft. thick. Considerable stripping will be necessary and a vertical face from 30 to 60 ft. high and about 1,200 ft. long will be exposed and the rock blasted off and loaded on cars drawn by locomotives to the crusher plant located about 500 ft. west of the axis of the Olive Bridge Dam. The stone will be delivered by derricks from the cars to the elevated charging platform of one No. 9 McCully rock crusher and two No. 6 Austin crushers, having a combined capacity of about 2,000 cu. yd. daily. The product of the crushers will be elevated, screened, stored in hopper-bottom bins of about 1,200-yd. capacity, and thence delivered by belt conveyors to four 1½ cu. yd. cubical mixers, which will deliver mixed concrete to 1½-yd. bottom-dump steel buckets hauled on flat cars to the cableways, which will distribute it to the mason's derricks along the line of the dam. The installation of the stone crushing and concrete mixing plant is now in progress, most of the machinery being supplied by the Power Mining & Machinery Co.

Adjacent to the concrete plant, there is now being prepared a yard for casting the concrete blocks for the face of the dam. This yard, about 200 ft. wide and 700 ft. long, is excavated to Elevation 543 and the material used for filling in the slopes of the dam. On it there will be established from end to end a narrow-gauge service track extending to the concrete mixer and parallel to the track of a 20 x 30-ft. traveling tower, about 6 ft. high, equipped with a derrick which will lift the concrete from the cars to the deck of the tower. The concrete will be shoveled from the elevated platform into wooden molds alongside, adjacent to the track on both sides. After the blocks are at least 48 hr. old, they will be stripped and the sides of the molds again assembled on other bottoms and new blocks cast, and so on. The old ones will not be moved, however, until they are at least 30 days' old, when they can be piled up by convenient derricks and stored until they have aged 3 months, after which they can be used in the dam. The general arrangement, equipment and operation of the concrete and block plant, is essentially the same as that very successfully adopted by the same contractor for the construction of the Cross River Dam, which was illustrated and described in The Engineering Record of June 16, 1906, and Jan. 5, 1907.

The 80 x 80-ft. frame compressor house is located near the crusher plant, about 500 ft. west of the dam; it contains two Ingersoll-Sergent air compressors, each with a capacity of 500 cu. ft. of free air per minute, which deliver into receivers supplying the distribution main, 10 in. in diameter at the compressor house, which distributes the supply to all parts of the main dams and dikes. Adjacent to the compressor house is a battery of horizontal boilers and an elevated coal trestle, with space under it for storing about 1,250 tons of soft coal. Some 1,500 ft. distant on the opposite side of the dam is a 48 x 136-ft. machine shop equipped with a planer, lathe, bolt cutters, shaping machine, drills and other standard tools sufficient for all ordinary repairs and for the construction of much of the machinery required on the work. Power is furnished by a 65-h.-p. engine of the General Electric make which also operates the General Electric dynamo for the electric light plant, equipped with about 600 lamps.

Adjacent to the machine shop is a 25 x 80-ft. main smith shop equipped with a steam hammer, bending machine and four forges with blast. A large stock of tool steel and iron rods and plates is kept, so that ordinary forge work and tools can be made and repaired from materials on hand. There is also a carpenter shop with saws, planers, boring machines and other usual tools for pattern making and general woodwork, which shop occupies a portion of the machine shop building, and there is a separate steam saw mill with a capacity of about 10,000 ft. board measure, of lumber daily. There is also a 32 x 125-ft. cement storage house, with a capacity for 5,000 bbl. of cement, a tool house and supply shop and several buildings for paint, oils and general storage.

Accommodation for about 100 mules is afforded by a reconstructed barn and by a new 32 x 170-ft. stable; a duplicate stable will provide for 60 more mules, besides which a large number of teams and wagons are hired from adjacent farmers. A separate stable is provided for office horses and for road teams. The 35 x 70-ft. office building has two stories, basement and attic and is pleasantly located on high ground about 1,000 ft. northwest of the Olive Bridge Dam. It is of attractive design, neatly and conveniently finished and arranged and contains the general offices, pay-rooms, drawing rooms, private office and reception rooms for the contractor's forces, together with a few bedrooms for the accommodation of assistants remaining constantly at the site.

At present the general water supply is distributed over the work through mains of a maximum diameter of 6 in. laid in trenches and provided with frequent hydrants and branches for service to different structures. Later on a 200,000-gal. concrete reservoir will probably be built at Elevation 640 on top of a hill about 1,500 ft. north of the power house, and water will be pumped into it from Esopus Creek to furnish a gravity supply for the entire work. A 10,000-gal. wooden stave tank already installed at this point supplies drinking water pumped from a spring about 1 mile distant. Plans have already been prepared for supplementing it with a 40,000-gal. reinforced concrete tank at Elevation 640.

There are at present employed on the work over 1,400 men, and as this number will probably be doubled before the completion of the reservoir, very complete and extensive arrangements are made for them.

The east slope of Winchell Hill, north of the dam and between the machine and office shop, has been reserved and improved for a camp. About 10 acres have been cleared, streets have been laid out and graded and a large number of workmen's houses, dormitories, barracks and so forth have been built. These form an attractive village located as shown on the accompanying map and providing for the comfort and welfare of most of the laborers and mechanics who, with their families, will eventually form a population of at least 5,000 or 6,000. The camp contains at present over 150 cottages, a 30 x 60-ft. one-story bakery house, a 38 x 100-ft. kitchen and dining room for the mechanics and skilled employees, a 30 x 100-ft. ice-house with a capacity of about 1,600 tons, a 25 x 40-ft. cold storage building, and a 32 x 100-ft. store or commissary building, which will provide food, merchandise and general supplies for all of the employees. There is also a somewhat isolated 26 x 38-ft. hospital now under construction, to provide 12 beds under the charge of trained nurses; and a school house and chapel will probably be built during the season.

The common labor, largely Italian and negroes, will be principally accommodated by barracks, of which seven 14 x 104-ft. one-story buildings have already been erected and more will follow. Each accommodates about 40 men, who usually divide themselves into groups of ten or a dozen each, with a cook to provide meals for the party. Four of the buildings are subdivided into a number of rooms holding from 6 to 12 men each and a large room for general cooking, and the other three are each divided into three rooms, the middle one having two tiers of bunks on each side and both end rooms being reserved for cooking. A better grade of bachelor laborers is accommodated by the four dormitories, each having beds for 24 men. The remainder of the men either come from adjacent villages, live with their families or board in the cottages in camp.

Grubbing and Removing Loose Rock on Surface of Site of Beaver Kill Middle Dike.

There have already been built about 100 four-room, one-story, 16 x 40-ft. cottages, with 12 x 12-ft. extensions. These have strong wooden frames, chiefly built from 2 x 4-in. spruce and supported 3 or 4 ft. above the surface of the ground on rubble masonry piers. They have no cellars, but the walls are continuous to the surface of the ground and are banked outside for greater warmth in winter. The houses have double floors and are ceiled inside with matched boards which also form the partitions, no plaster being used. The walls and roof are covered outside with rough spruce or hemlock, covered with rubberoid or Amazon paper, 1 ply thick for the roof and ½ ply for the walls, laid in continuous horizontal strips with the joints painted and guaranteed for seven years. They have no chimneys, but are provided with galvanized iron smoke flues and each cottage has 8 balanced sash windows.

All of the fuel necessary for heating is included in the rental of the cottage and water is supplied from exterior hydrants. There are also about 50 better cottages of about the same size for mechanics and foremen. Each cottage is provided with a separate outdoor closet built in groups of one, two or four, according to location. The closets have a concrete vault about 4 ft. deep, 2 ft. wide on top, with a wedge-shaped cross-section tapered to a width of 8 in. at the bottom, which is composed of a horizontal terra-cotta half pipe connected at both ends with a whole pipe. Two-inch waste pipes from the kitchen sinks discharge through the vault, and each vault is provided with a 2-in. pressure pipe enclosed in a 4-in. terra-cotta shell and controlled by a valve located outside and periodically operated by an attendant whose duty it is to flush all closets twice daily or oftener.

The 6, 8 and 10-in. sewer pipes discharge into a 12-in. vitrified sewer pipe at an average depth of about 4 ft. below the surface with a grade varying from 0.27 to 7 per cent., provided at all bends and intersections with manholes and cleaning holes. These discharge into a concrete well, 10 ft. in diameter and 10 ft. deep, in which there are two 10-in. outlets to a pair of 15 x 40-ft. septic tanks, 5 ft. deep, with concrete bottoms and sides. These tanks overflow through vitrified pipes to perforated wooden distributing troughs, which discharge over the surface of an open 60 x 90-ft. filter bed 4 ft. deep, filled with broken stone. The effluent rises from a bottom outlet through an aerating well and is thence discharged through an 8-in. pipe about 150 ft. long to the Esopus Creek. The effluent is subject to periodical examination and bacterial and chemical analysis by the New York City Board of Health and is expected to be clear and inoffensive. The plant has an estimated capacity of 40,000 gal. daily.

The reservoir has been designed and is being constructed under the direction of the Board of Water Supply, Messrs. J. A. Bensel, Chas. M. Chadwick and Chas. A. Shaw, commissioners; Mr. J. Waldo Smith, chief engineer; Mr. John R. Freeman, Prof. W. H. Burr and Mr. Frederick P. Stearns, consulting engineers; Mr. Alfred D. Flinn, department engineer, headquarters department; Mr. C. E. Davis, department engineer, reservoir department; and Mr. J. F. Langthorn, division engineer. The general contract was awarded to MacArthur Bros. Co. and Winston & Co. Mr. M. J. Look is general superintendent and Mr. Harry A. Briggs is engineer for the contractor.

Some Recent Steel Cage Buildings in San Francisco.

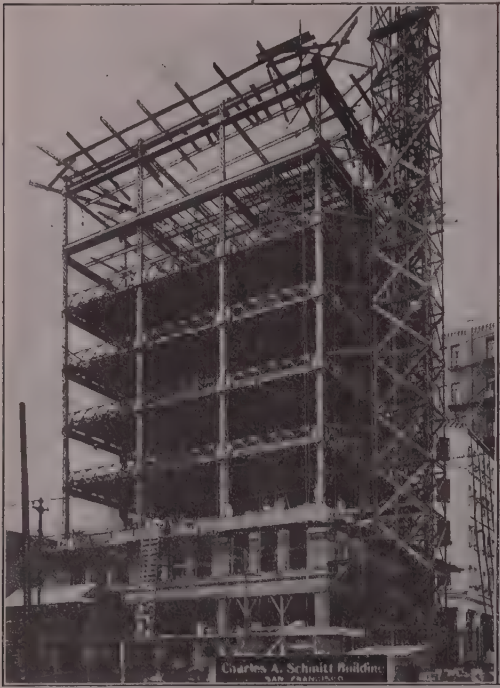
Since the conflagration which destroyed practically all of the business part of San Francisco in April, 1906, a large number of commercial and office buildings have been constructed on the devastated area. The more important of these buildings, at least, have been designed to conform not only to the general requirements of advanced practice, but also to combine fire-proof qualities with a considerable resistance to seismic disturbances. As many of these buildings correspond in their general features, a brief review of a group embracing various heights and styles and adapted to occupation for various purposes will serve to show the types that have been erected.

Nearly all of these buildings have been constructed in open spaces where all of the former structures have been destroyed and completely removed, and the new ones had in general the advantage of being built without serious restriction from adjacent property and without special difficulties involved in the construction of their foundations. Their sites are located either on a level fill about 10 ft. above tide water in the lower part of the city, or on the adjacent higher ground, which, within the area of the burned district rises to a height of about 25 ft. above the low level.

On the low ground the fill is chiefly of earth, loam and rubbish and in all cases is excavated to or beyond the ground water line, below which it constitutes a stratum of mud of varying depth. On the higher ground, and underlying the fill, the soil consists of clay and sand of considerable depth, dry at the surface and containing a moderate amount of water below tide level. It is easily excavated by pick and shovel and requires sheeting in pits.

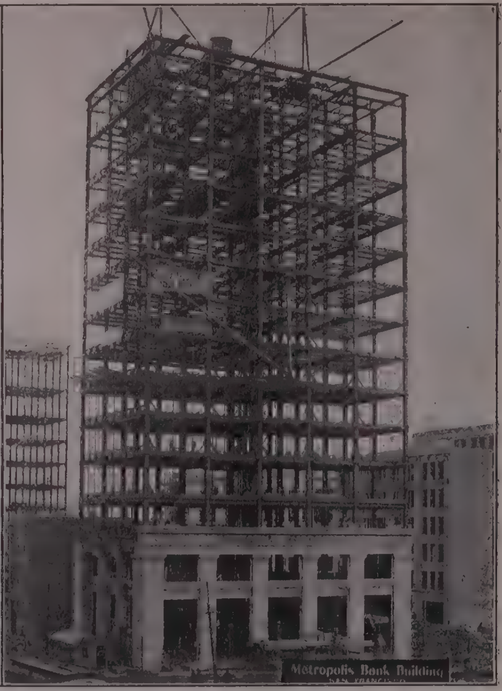
The San Francisco building law makes each owner responsible for the safety and integrity of his own foundations regardless of adjacent operations and it has therefore been considered good judgment, in cases where there was believed to be a possibility of deep foundations for the construction of very heavy structures adjacent to safeguard the new building as much as possible from settlement or undermining which might be threatened by future operations. The general practice has been to make the excavation to or a little beyond ground water level and when solid satisfactory soil was found at that level to construct on it grillages of steel I-beams embedded in concrete, or footings of reinforced concrete proportioned to reduce the maximum load on the soil to about 4 tons per square foot. Where the soil is wet and soft the foundations have generally been made with wooden piles cut off below water level, capped with concrete footings, often enclosing steel I-beams, and proportioned for a load of 15 to 20 tons per pile.

Since the earthquake and fire and up to 1907 the maximum height of buildings was limited to one and a half times the width of the street, which resulted in a fairly uniform average of about 100 ft., or eight stories above the curb and one story below it. This restriction has been very recently removed and no height being now prescribed, some of the latest buildings are being designed and constructed up to fourteen stores. None have yet been built, however, as high as the Spreckles Building, which is 310 ft. from the curb to the top of the dome as described in The Engineering Record of April 9, 1898, and is notable for its successful resistance to both earthquakes and fire hazard. This building is about 75 ft. square and is seated on a solid continuous platform, nearly 100 ft. square and 25 ft. below the surface of the ground, composed of two crossed tiers of full length steel I-beams, set close together and embedded in a mass of concrete 4½ ft. thick, with the columns securely anchored by heavy tension bars to beams in the lower tier.



The Charles A. Schmitt Building.

The Eyre Building.



The Metropolis Bank Building.

The building law requires provision for 30 lb. wind pressure on all vertical surfaces and provides that the unit wind stresses may be increased 50 per cent. above the dead load stresses, thus allowing them to be 18,000 lb. per square inch of the steel. Unit stress in the steel columns are taken at 12,000 lb. per square inch up to $L \div R = 90$, above which they are reduced in accordance with the column formula. The usual allowance is made for a dimished percentage of the total load of the floors considered simultaneously transmitted to the columns from the top downward.

A group of fifteen buildings erected by the Thompson-Starret Co., New York, since the disaster are mostly located in the low ground, many of them on Kearney St., where the water level is about 14 ft. below the surface and the excavations were made with pick and shovel and team work, the spoil being in many cases loaded on wagons and drawn up inclined planes and in other cases shoveled into steel buckets and loaded by derricks into wagons at street level. All of the excavations were protected by square-edge wooden sheeting, usually 2 or 3 in. thick and 12 to 15 ft. long, driven by hand as the work progressed. Pumping was required only where foundation excavations were made in filled ground.

The fifteen buildings referred to have fronts varying from about 50 to 140 ft. long and are from four to fourteen stories in height. They also include one building in Oakland and another in San Francisco, the latter being seven stories high and built entirely of reinforced concrete. Nearly all of them have stone or terra-cotta fronts and reinforced-concrete side and rear walls and reinforced-concrete slab construction for floors and roof.

Of all the buildings in San Francisco contracted for since the fire, the Eyre Building at Kearney and Sutter Sts., was the first one to be completed. It has fronts of 56 and 66 ft., and is eight stories and basement in height. The street fronts are of cut granite, with carved trimmings in the lower stories, terra cotta trimmings above and a steel and terra cotta cornice. The framework is of very simple standard construction with closed rectangular two-story riveted columns and I-beam girders and floor beams. The column and girder connections are made with gusset plates to give stiffness against wind pressure. All steel work is completely enclosed in concrete. That for the columns has a minimum thickness of 3 in. and is reinforced and secured by small horizontal rods, about 12 in. apart vertically with their ends twisted together at the corners of the column.

The foundations are steel I-beam grillages seated on concrete footings about 4 ft. below the curb level and receive their column loads through standard cast-iron pedestals with grouted bearings on their top flanges. As it was anticipated that deep foundations may hereafter be constructed on the adjacent lot, the integrity of these foundations was safeguarded by the construction of a concrete retaining wall below the cellar floor. A sheeted trench 120 ft. long was carried down to a depth of 40 ft. below the curb with considerable difficulty and involved a large amount of constant pumping. In it was built a wall 25 ft. high with a uniform thickness of 5 ft. The sheeting was pulled on both sides of it and the trench was back-filled and rammed so that little apprehension is felt from the development of unbalanced pressure induced by any future excavation in the neighboring lot.

The retaining wall and foundations were made with 1:2½:5 concrete, Portland cement and 1½-in. broken stone, mixed in a Ransome machine located at street level and delivered through a chute into the wall trench, the machine being moved along as required from end to end of the trench. The concrete for the foundations, cellar floor and retaining walls was delivered in 1-yd. steel buckets handled by a guyed derrick with a 60-ft. boom of 10 tons capacity.

The derrick was at first located near the center of the lot in the bottom of the excavation and after the foundation work was completed was moved up from story to story with every second tier of beams. It commanded the whole area of the building and both street fronts and was thus able to handle all material, and to unload and erect all of the 500 tons of structural steel in the building.

The contract for this building was awarded in August, 1906, excavation was commenced October 1, and the setting of the grillage beams was commenced about the middle of January, 1907. The erection of the steel framework was completed February 16, the outer walls were finished about May 1, and the building was ready for tenants July 1. Mr. L. B. Dutton was the architect.

Another steel-cage building is the 54 x 127-ft. 7-story structure on California St. for the Welch Estate. The soil here is a 10-ft. fill with the water-level 9 ft. below the curb and the three longitudinal rows of columns are seated on steel grillages with concrete footings supported on and enclosing piles from 25 to 30 ft. long driven to a refusal of 2 or 3 in., in open sheet-pile cofferdams, cut off below water level and loaded to a maximum of 15 tons each. The tops of the grillages are below the unobstructed cellar floor, which is itself 6 in. above water level. The reinforced-concrete cellar retaining walls and the cellar floor are waterproofed in the usual manner with tarred felt.

The structural steel weighs about 600 tons and is of simple standard design, with details corresponding to those already described for the Eyre Building. It was erected with an average force of about 20 men in about 60 days by a single centrally located stiff-leg derrick, with a 60-ft. boom of 10 tons capacity. The derrick was raised every second tier in the same manner that is customary for a guyed derrick, the unshipped boom serving at a gin-pole to hoist the mast, stiff-legs and sills, which were handled without being taken apart. The derrick was usually shifted in about 4 hr. by a force of 6 men, and when in service was anchored by screwed clamps to the erected girders. It was operated by a double-drum Lidgerwood hoisting engine permanently located in the cellar. The boom commanded the street and unloaded the steel from wagons there, often erecting the columns and girders without rehandling, and at other times storing them temporarily on the upper tier in positions convenient for erection as required.

In this building all of the walls are of brick, which in the street front was laid from an exterior scaffold suspended by Manila tackles from 12 x 16-in. horizontal beams about 25 ft. long and 8 ft. apart laid on the finished roof with their rear ends anchored to the girders and the opposite ends cantilevering about 8 ft. beyond the front wall girder and passing through the cornice framework to support the outside suspension tackles.

Construction was commenced about the first of March, the foundations were completed in April, the steel work was all erected by July 1, the exterior wall was finished early in October and the building was ready for tenants January 1, 1908. Mr. O. G. Traphagen was the architect.

The 60 x 90 ft. fourteen-story Metropolitan Trust and Savings Bank Building on Market Street has about 900 tons of structural steel in its framework, which was completed in 60 days by an average force of 40 men. Its steel columns have cast-iron bases seated on concrete footings at a depth of about 14 ft. below the curb. The exterior walls are supported at every floor by special girders, which have such deep and rigid connections to the columns that special wind bracing is considered unnecessary.

The cellar excavation, 12 ft. in depth, was protected by hand-driven wooden sheathing and is enclosed by a massive monolithic-concrete retaining wall, without reinforcement, which was cast in forms built up like those usually adopted for buildings and removed after its completion. The wall does not depend for its strength on bracing provided by beams and girders at street level as many basement retaining walls do, but has independent stability due to its own weight and strength and a base with a width of one-fifth of its height. All of the excavation and erection work was handled by a single stiff-leg derrick and neither the design nor construction was of unusual character. Mr. L. B. Dutton was the architect.

The 60 x 60-ft. eight-story Schmidt Building has cast-iron column pedestals seated on I-beam grillages and has reinforced-concrete floor slabs, cut-stone front walls and red brick rear walls. The steel framework is of standard construction, except that in every lower tier the wall columns support lattice-girder wall beams about 5 ft. deep, with their top flanges just clearing the window sills. Their deep web connections to the columns give great transverse rigidity to wind stresses and vibrations and are relied on to provide adequately for any earthquake shocks to which the building may be subjected. In the eighth and ninth tiers the lattice girders are replaced by plate girders 30 in. deep. The interior floorbeams and girders are of the usual I-beam type, of maximum spans of about 16 ft., and have web and flange connections to the columns.

During erection the principal front was provided with a protecting platform over the sidewalk, which was used for the contractor's office, storage and stone cutting. The front walls were laid from platforms suspended by steel ropes from cantilever beams anchored to the upper tier of I-beams. The platforms extended continuously around the two sides of the building and were moved up together. All brick and concrete was hoisted by hod elevators operated in a tower constructed in the middle of one front of the building on the sidewalk. This building contains about 500 tons of structural steel, erected by the general contractor, as in the other cases mentioned. Its steel erection was completed in 45 working days. Mr. Albert Pissis was the architect.

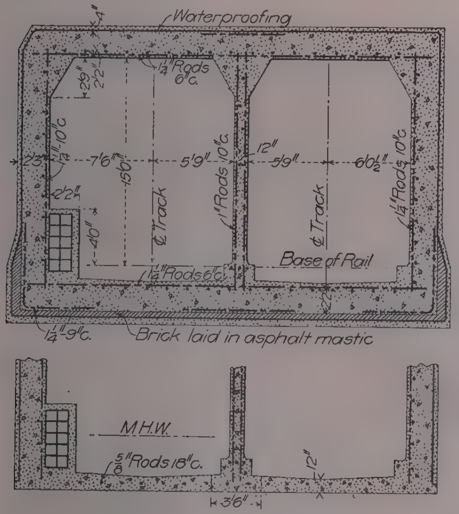
For all the buildings here described the general contractor was the Thompson-Starrett Co., New York, Mr. George Simpson, chief engineer, and Mr. Louis R. Bowas, superintendent in charge. The structural steel was fabricated at the Pencoyd plant of the American Bridge Co.

A 12,000-H.-P. STEAM TURBINE UNIT has recently been built by Signor Franco Tosi, of Legnano, near Milan, Italy, which is the first of three that are under construction for a central station in Buenos Ayres, Argentina. The turbine design is of the Parsons type, with the blading of three stages carried on a single hollow forged-steel drum which is supported by projecting shafts in bearings 19.28 ft. between centers. The projecting shafts are mounted in steel heads shrunk into the ends of the drums. The minimum clearance provided for above the blade ends is 1.8 mm. The turbines are intended for operation at 760 r. p. m., with steam at 175 lb. and superheated to 570° Fahr. and the steam consumption is said to be approximately 14.1 lb. per kw. hour. The steam end is 30.5 ft. in overall length, has an overload capacity up to 14,200 h. p. and has weights of 49 tons for the cylinder and 23 tons for the rotor with blading. The distributing valve gear controlling the steam inlet is not actuated by steam as in the Parsons turbine, but by oil under pressure taken from the force lubrication system. As a result, the turbine cannot be started until the oil supply pump is started, so that the bearings are always assured a supply of oil. Special features of the system of steam distribution render the speed of the turbine largely independent of variations in steam pressure, an important advantage for use under fluctuating loads.

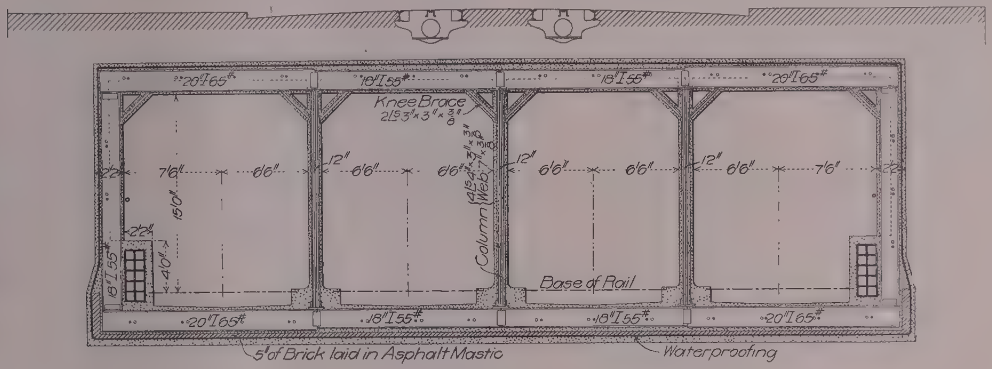
Construction of Section 903 of the Bridge-Loop Subway, New York City.

The extension of the municipal rapid transit railway system, now under construction to improve the Manhattan connections and terminals of three of the East River bridges in New York City, is generally known as the bridge-loop subway, although it is not, strictly speaking, a loop. It will consist of a four-track line, nearly 7,000 ft. long, extending from the Brooklyn Bridge approach to the Williamsburg Bridge approach, with tangent connections at each end to the bridge tracks, and of a two-track branch, about 1,800 ft. long, to the Manhattan Bridge approach. None of these tracks have loops, or provide for a continuous circuit, in the sections under construction, but, as they are intended to permit the continuous operations of cars from one bridge to another and to connect the bridge service with the street railway system, dispensing with the shuttle service on the bridges and dead ends of tracks or restricted terminals there, they do in reality form elements of a large loop system and justify their designation.

Four tracks extend from the Manhattan entrance of Brooklyn Bridge, northerly about 4,000 ft. on Center St. to Broome St., where they turn a right angle and pass through an 80-ft. extension of Delancey St. to the Bowery, and thence down Delancey St. to the Williamsburg Bridge approach. The double-track connection for the Manhattan Bridge branches off from the four-track lines at right angles and runs down Canal St. to Christie St., forming a part of contract section 902. The four-track section is divided into contract sections 901, 902, 903, 904 and 905, of about equal length, commencing at the Brooklyn Bridge entrance, and has underground stations at City Hall Place, at Canal St. and at the Bowery; the first-mentioned section being nearly, or quite, the largest ever yet constructed.



Double Track Section.



Typical Four-Track Section, Bridge-Loop Subway.

The general features and location of the structure conform to the plan originally adopted by the Rapid Transit Railway Commission, on which the construction contracts were awarded. Since the work has come under the control of the Public Service Commission, the problem has been analyzed on somewhat different lines, and the plans have been reconsidered and materially changed in detail and in some important features of construction. It was at first proposed to build in some places a double-deck subway, involving very deep and difficult construction and steep grades and to use the reinforced-concrete type of walls and roofs throughout, except where special provision was required for very heavy loads.

The plans have now been revised to eliminate all of the double-deck structure and to avoid deep excavation or steep grades, and a considerable part of the walls and roof will be made with steel beams and columns. An increased vertical headway is provided, which allows the use of standard cars in the subway. All steel work is entirely enclosed by concrete, and the electric ducts have been arranged in benches inside the walls rather than outside, as before, thus making them much more convenient and accessible. Pipe drains under the tracks have been eliminated, and in their place sumps have been provided to receive the water which is collected on the invert by the inclination of its upper surface from both sides to the center line. At curves and stations and where heavy overhead tracks are to be carried, or where the foundation is precarious, special construction is provided for.

Some of these changes from previous construction appeared in the original plans for the bridge loop and others originated in the revision. Among the most important of these are the increased vertical clearance, the abolition of double decks and the introduction of continuous longitudinal interior walls, all of which have been made by the Public Service Commission.

The four-track subway has a rectangular cross-section, about 62 ft. wide and 23 ft. deep, to sub-grade, with a concrete roof, supported on transverse steel bents, 5 ft. apart. Each bent has 18 and 20-in. transverse I-beams, supported on and knee-braced to intermediate riveted columns, 14 ft. apart, with I-shaped cross-sections, made up of solid web plates and four flange angles and wall columns, made with 18-in. I-beams, having their webs engaged between the vertical concrete arches forming the side walls. Where sub-grade is much below the ground-water line the columns are seated on continuous transverse I-beams corresponding to the roof girders, which are enclosed with concrete made continuous with uniform thickness from beam to beam.

The angle iron knee-braces are enclosed in concrete, as are the columns themselves, and the latter protection is extended from bent to bent to form a solid, continuous concrete partition wall between tracks, pierced with doors every 10 ft. and serving not only to promote their ventilation, but to safeguard the structure from dangerous impact in case of derailment. In all cases the roof and side walls are waterproofed by the standard asphalt process, and where the invert is below the ground-water line the waterproofing on the walls is flashed continuously with a horizontal sheet carried across the full width of the excavation and embedded in the concrete below the bottom flanges of the beams.

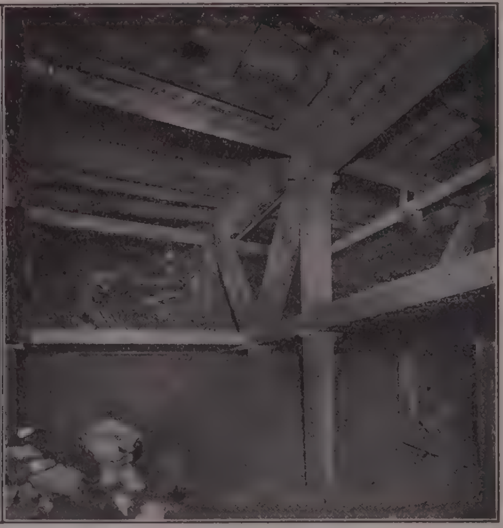
Where sub-grade is above the ground-water line the lower transverse beams are omitted, and the columns are supported on continuous, reinforced-concrete footings, under which the soil is previously compressed, in order to avoid possibility of settlement of the completed structure. Between the footings the invert consists of a 12-in. continuous slab of concrete.

The double-track subway is about 32 ft. wide over all, and sub-grade is about 23 ft. below the street surface for the standard cross-section. The latter is made entirely with reinforced concrete and has a roof slab 32½ in. thick, reinforced near the lower surfaces with ⅝-in. square, longitudinal bars, 18 in. apart, and transverse 1¼-in. bars, 6 in. apart on centers. It is supported by the side walls and by a continuous center wall, 12 in. thick, reinforced near each surface with 1-in. vertical rods, 10 in. apart, and ⅝-in. horizontal rods about 2 ft. apart. The side walls are 2 ft. 3 in. thick and are reinforced near the inner surface with 1¼-in. vertical rods, 10 in. apart, and ⅝-in. horizontal rods, 18 in. apart.

The angles between the walls and roof are filleted with solid masses of concrete about 3 ft. deep, with surfaces inclined about 30 deg. with the vertical, thus making a sort of continuous knee-brace. The wall footings are integral with the floor, which is about 3 ft. thick and is reinforced like the roof, and also have 1¼-in. rods, 10 ft. long, bent to right angles and placed 9 in. apart in the lower corners. Where the invert is above the water level the floor is made like that of the corresponding four-track construction, with a continuous 12-in. concrete slab. Where the location of the tracks interferes with the center wall the latter is omitted, and the roof is carried on plate girders, 4 ft. deep, supported by 15-in. I-beam wall columns.

The excavation for this section of the subway is from 60 to 70 ft. wide, extending in some places beyond the curb lines and intersecting the old sidewalk vaults, and has a depth of from 24 to 36 ft., involving a total excavation of 50 to 60 cu. yd. per lineal foot, all of which is in earth varying from clay to fine, sharp sand. Many obstructions exist here, as in other parts of the subway, consisting chiefly of sewer, water and gas pipes, electric conduits and pneumatic mail service tubes; most of these were located a little below the roof of the subway, which has a minimum clearance of only 4 or 5 ft. below the surface of the street. Owing to the difficulty of maintaining the pneumatic tubes in service, free from any displacement or interior condensation during construction, these tubes were relaid by the contractor on Park and Mulberry Sts. before the commencement of the work, so that the old tubes will give no difficulty and can be removed whenever encountered in the excavation. A high-pressure water main under from 350 to 450 lb. constant pressure was located just below the tunnel roof at Broome St. and is temporarily supported from the timbering, but will eventually require to be raised and seated on permanent supports on the subway roof. Other gas and water mains, electric conduits, and so forth, are more easily handled and shifted as requisite to finish the structure.

Wood Pipe Diversion Sewer.



Timbering and Excavation.

A main, 3½ x 4-ft. brick sewer, in the center of the street will be replaced by two 18-in. pipe sewers, one on the exterior of each side wall of the subway, which pipes will be built as the subway walls are constructed. Meantime, a preliminary trench was dug along the line of the subway close to one side, and in it was installed about 550 lin. ft. of a cylindrical wooden sewer, 3 ft. in diameter, built with 3 x 4-in. planed staves, with square butt joints and turnbuckle hoops, 5 ft. apart. This pipe is supported on transverse bents from the sub-grade of the trench and at each end is concreted into a wooden junction box, connecting it with the old sewer and permitting the intermediate portion of the latter to be removed as the excavation proceeded.

Construction operations were commenced under the old plans July 1, 1907, by replacing the entire stone-block pavement between the curbs and the double-track street car line in the center of the street with a solid deck of 4-in. transverse plank, supported on 6 x 10-in. longitudinal stringers laid in shallow trenches 3 ft. apart on centers. This platform was put down in strips about 13 ft. long, parallel with the axis of the subway and 20 ft. wide from curb to street car track. A 12 x 12-ft. opening was left in it at Grand and Center Sts., where a 50 x 60-ft. elevated platform was built at a clear height of about 15 ft. above Center St. and was supported on long transverse 24-in. I beams, knee-braced to vertical posts seated on the curb lines. A stiff-leg boom derrick was installed on this platform to command the opening in the street deck and to hoist the spoil and deposit it in storage bins of about 20 cu. yd. capacity, from which it was delivered through steel gates operated by hand levers to dump wagons in the street, which could thus be loaded in a minute or two at any time, without regard to the conditions of hoisting and without interrupting traffic in the street.

A cut, about 7 ft. deep and 12 ft. wide, was commenced at the deck opening and drifted transversely across the full width of the subway, the longitudinal platform stringers being supported in the usual manner by blocking and short, vertical shores carried down as the excavation progressed. After a transverse cut had been established from the curb to the car tracks on each side of the street headings were commenced on opposite sides of each cut and were pushed away from each other, completing the full-width excavation of the upper lift of the trench. When the headings were about 50 ft. apart lines of 18-in. gauge tracks were installed and equipped with flat cars and 1-yd. bottom dump buckets, the spoil being delivered in the latter through the openings in the deck where it was hoisted by the derricks.

Transverse timbers, 5 ft. apart, were located to clear the columns of the finished subway structure and were wedged up on vertical posts, arranged as shown in the accompanying cross-section, with their feet supported on 6 x 12-in. needle beams, made in 10 to 15-ft. lengths, with square butt joints laid on the bottom of the excavation. The track rails and cable conduits for the double-track surface car line in the center of the street have a continuous monolithic foundation about 20 ft. wide and 3 ft. deep. This was not disturbed by excavating the upper lift of the trench on both sides; after that work was completed, the base was undermined a few feet from each side; longitudinal planks were placed against the bottom of the concrete to prevent detached portions from falling, and horizontal transverse poling boards, about 8 ft. long, were driven in from both sides and supported at their outer ends on blocking until small drifts could be tunneled through the remaining core under the center of the concrete and transverse needle beams about 7 ft. long inserted. The excavation under the concrete was then continued until clearance was afforded to set four pairs of longitudinal, horizontal 8-in. I-beams under the poling boards and needles, which supported them by wedges and blocking, so that the excavation could be continued under the tracks across the full width of the trench. A second lift, about 10 ft. deep, was then made on each side of the trench, and the two connected by a shallower transverse excavation, permitting a center arch, made with three 12 x 12-in. segmental timbers for each bent, to be erected, and vertical, horizontal and inclined posts, to be placed on each side of it, as shown in the diagram.

Down to this level the excavation always extended to or beyond the sidewalk vault lines, so that no sheeting was required to retain the outside faces. After the excavation at this level had attained a length of about 50 ft. the surface tracks were removed from the upper bench and reinstated on the second bench, and a third cut extending to sub-grade was commenced. The benches were carried forward, with an average distance of about 30 ft. between the headings. The surface tracks were permanently installed at sub-grade, and the cars on them were drawn by mules to the foot of the derrick, where a loop was constructed to enable them to be unloaded and returned to the headings without delay, thus facilitating work on the excavation.

The sides of the lowest cut were retained with 2-in., square-edged sheet piles, driven by mauls, as the excavation progressed, and four continuous lines of longitudinal tie-braces were inserted in the planes of the vertical posts of the second and third tiers. These braces were made with 15-ft. lengths of 12-in. channels, bolted together back to back, with fillers between their webs and with staggered splices serving to tie the bracing thoroughly together. These members also serve as girders, which permit the spacing of the second-story bents to vary slightly and also serve as stringers to carry the material track. All of the spoil is excavated by shovels and is thrown from the upper bench to the second one, where it is carried by systems of belt conveyors, 20 and 45 ft. long, to a point beyond the lower bench, where it can be dumped directly into the bucket on the permanent surface tracks.

About 400 ft. of the excavation adjacent to Section 904 has been completed, and in it the concrete has been laid over the full width of the bottom for a length of about 100 ft., completing the finished floor for this portion of the subway. The construction of the walls and roof awaits the fabrication of the steel columns, which have been delayed by the change of plans. A second overhead platform has been built in the street at the opposite end of this excavation, and from it the excavation of the full-width trench is proceeding, as already described, toward Section 902. The concrete is made with Giant Portland cement and is hand-mixed at the street level and delivered in wheelbarrows to sheet-iron chutes which discharge it wherever required for the floors or for the sidewalls that are built with it up to a height of 2 ft. No water has been encountered, and the excavation has been carried on rapidly and continuously.

The original plans on which the contract was awarded called for the construction of one track at a depth of about 45 ft. below the surface, enabling it to cross under the other tracks. This involved an excavation in quicksand to a depth of about 22 ft. below the ground-water level. It was planned to make this excavation with wooden pneumatic caissons, 20 ft. wide, 110 ft. long and about 20 ft. high, which were to be built in the trench at about the level of sub-grade for the higher tracks and would, of course, be left permanently in the ground; the change of plan obviated the necessity for this construction, but the contractors had already installed a complete air compressor plant, with a capacity of 7,500 cu. ft. of free air per minute. As no rock drills are required on the work and the hoisting engines are all supplied with independent steam boilers, the air plant is not at present in service, but may later be used to operate pneumatic hammers for riveting the steelwork. Besides the compressors the other principal items of plant installed on this section include two double-drum hoisting engines, two 20-in. belt conveyors, built by the contractor and operated by General Electric motors of 2 hp. each; ten 1-yd. Stuebner bottom-dump steel buckets, eight Koppel flat cars and about 1,000 lin. ft. of 18-in. gauge tracks, with switches, crossings, and so forth, together with the usual equipment of hand tools.

Great pains have been taken to make the different pieces of bracing and shoreing standard and as nearly as possible interchangeable, so that no time is lost in selecting or fitting. All of them are framed on the surface and are cut in lengths easily handled in the trench. About 30 tons of 20-in. I-beams, in lengths of about 25 ft., have been used in the underpinning of adjacent buildings, many of them being left permanently in the work. In most cases this work has so far been of the ordinary nature and has been executed without special difficulty; the section below mean high-water level not yet having been commenced. The total amount of excavation is estimated at 82,000 yd., of which over 25,000 yd. has been accomplished.

The subway is being built under the direction of the Public Service Commission, Mr. Henry B. Seaman, chief engineer; Mr. Geo. S. Rice, engineer of subways; Mr. Alfred Craven, deputy engineer of subway construction; Mr. Sverre Dahm, engineer of designs, and Mr. G. H. Clark, division engineer. The contract for Section No. 3 was awarded to the Cranford Co., Mr. J. C. Meem, consulting engineer, and Mr. Howard Robinson, superintendent.

THE LAYING OF GAS PIPES in some of the streets of Chelsea, Mass., has been opposed by the authorities of that city, but the Supreme Judicial Court of the state has recently decided in a voluminous opinion that a company which has received the legislative permission to lay its mains through highways can do so even when the authorities of the cities traversed by the pipes oppose this work. In this particular case the mains were intended to convey gas from Everett into Boston, and were not for supplying the citizens of Chelsea. The court ruled that laying a pipe line under a public street does not impose an additional servitude upon abutting property, so that the owners of the land must be compensated for the privilege. The general rule in Massachusetts is stated to be that when land is taken for a highway all uses of the land directly or incidently conducive to the enjoyment of the public easement which the necessity and convenience of the public may require, either then or in the future, are paid for. In this case it was contended that as the pipe line was not for the use of the people of Chelsea, its presence could not be considered beneficial to the adjoining property and therefore could not be regarded as fairly incident to the public use of the highways. The court ruled that this is not a correct contention because the roads have been established for the common good of all inhabitants of the Commonwealth. The fact that their cost falls to a large extent upon the cities and towns in which they are situated, gives to those communities no peculiar privileges. "The powers which have been given to cities and towns by the legislature, by special or by general laws, are in no sense a contract, and do not become vested rights against the legislature." The ruling of the court was that when a company secures the right to lay its pipe in the streets of a town, the officials of the latter simply become the agents of the legislature in carrying out whatever regulations the legislature may indicate as desirable in connection with the construction of these mains.

The Design of Retaining Walls.—I.

By Harold A. Petterson, Office Engineer, Los Angeles Aqueduct, Los Angeles, Cal.

Retaining walls have been discussed frequently by contributors to technical journals, and the discussion shows that while the majoritiy of engineers in the United States agree upon a method of determining earth pressures, they do not, however, agree upon the methods of proportioning a wall whose earth pressure and height have been agreed upon.

The purpose of this article is not to discuss the various theories of earth pressure, but rather to discuss the most economical forms of wall for sustaining earth pressures, and to compile tables and diagrams which will facilitate their design. Masonry walls of gravity section and reinforced concrete walls will be considered.

The following nomenclature and symbols will be used:

AB = Back of wall.
CD = Face.
h = height of wall in feet.
b = width at base in feet.
H = horizontal component of earth pressure in pounds per lineal foot of wall.
t = intensity of horizontal earth pressure in pounds per square foot.
M_t = overturning moment of earth pressure expressed in foot pounds.
M_r = resisting moment of wall expressed in foot pounds.
w = weight of earth in pounds per cubic foot.
m = weight of masonry in pounds per cubic foot.
ϕ = angle of repose of earth measured with the horizontal.
X = spacing of ribs in feet, center to center.
d_1 = average thickness of wall in inches.
d_2 = thickness of base slab in inches.
d_3 = thickness of toe.
E_s = modulus of elasticity of steel in pounds per square inch.
E_c = modulus of elasticity of concrete in pounds per square inch.
S = unit value of steel in tension.
C = unit value of concrete in compression.
M = bending moment as applied to beams, slabs, etc.
b_1 = width of beams, slabs, etc.
$K = M \div b_1 d^2$ (Taylor and Thompson formula).
p = maximum intensity of earth pressure on foundation in pounds per square feet.

Gravity Walls.—Trautwine treats of gravity walls in his handbook and gives relations of safe width of base to height of wall for various kinds of masonry. The writer proposes to amplify this discussion for gravity walls and to show that the width of the base varies not only with the specific gravity of the masonry, but also with the form of wall, the unit weight of the earth backing and the angle of repose of the earth.

Theories of Earth Pressure.—

Let H be assumed to act at a distance of 2/3 h from top of wall.

$$H = h^2 w \tan^2 (45^\circ - \tfrac{1}{2}\phi) \div 2 \qquad (1)$$

$$M_t = H\,h/3 = h^3 w \tan^2 (45^\circ - \tfrac{1}{2}\phi) \div 6 \qquad (2)$$

Equations 1 and 2 are the generally accepted formulas for determining earth pressure. The usual value of ϕ is 45 deg. corresponding to a 1 to 1 slope, and the value of w is generally taken at 100 lb. per cubic foot. The weight of earth, however, varies from 90 to 140 lb. per cubic foot. The writer has taken three values for w, viz, 100, 120 and 140 lb., and has based designs upon these three values. The angle of repose varies considerably with different kinds of material, so that it is not safe in one case or economical in another to use the one value of $\phi = 45$ deg. In extensive retaining-wall construction the engineer is warranted in making field studies to determine the angle of repose of the earth he proposes to retain by his structure. In the construction of smaller walls, the angle of repose can be determined from judgment and a knowledge of the ground where the proposed wall is to be built.

TABLE I.—VALUES OF ϕ, H AND Mt.

Angle of Repose.			H in lb.	Mt in ft. lb. $=awh^3$.	$\tan^2(45°-\frac{1}{2}\phi)$
Slope.	Deg.	Min.			
¼–1	75°	58′	$0.0076wh^2$	$0.00253wh^3$	0.0152
½–1	63°	26′	$0.0278wh^2$	$0.00928wh^3$	0.0557
1–1	45°	00′	$0.0857wh^2$	$0.02858wh^3$	0.1715
2–1	26°	34′	$0.1910wh^2$	$0.06365wh^3$	0.3819
3–1	18°	26′	$0.2599wh^2$	$0.08663wh^3$	0.5198

REMARKS: h is in ft., w in lb. per cu. ft.

The writer has used five values of the angle of repose from which can be selected the value of ϕ most nearly corresponding to the particular case in hand. These values of ϕ, and also values of H and M_t, are compiled in Table 1 for convenience of reference.

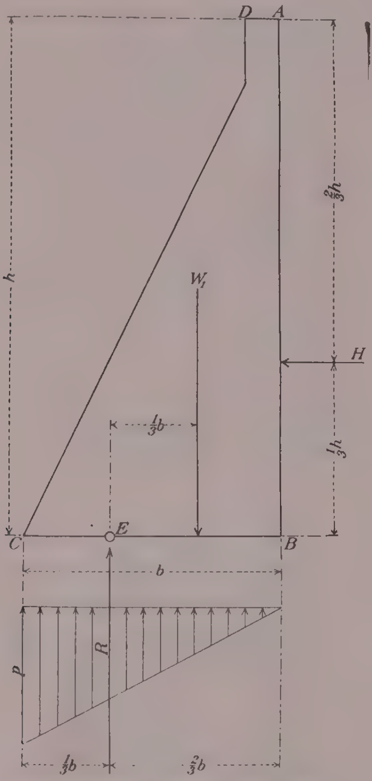


Fig. 1. Wall with Vertical Back.

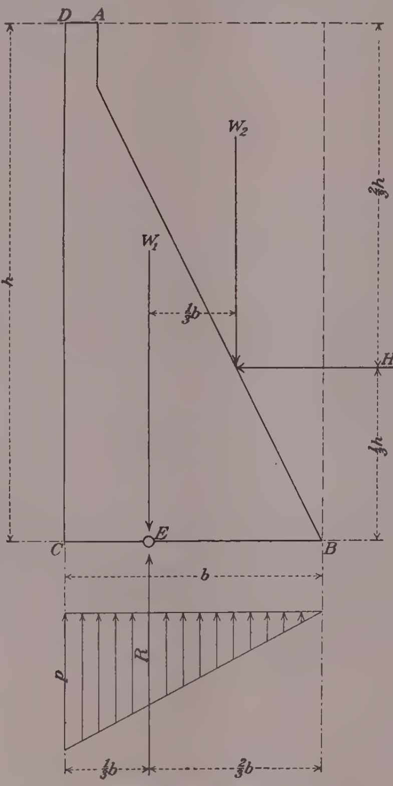


Fig. 2. Wall with Vertical Face.

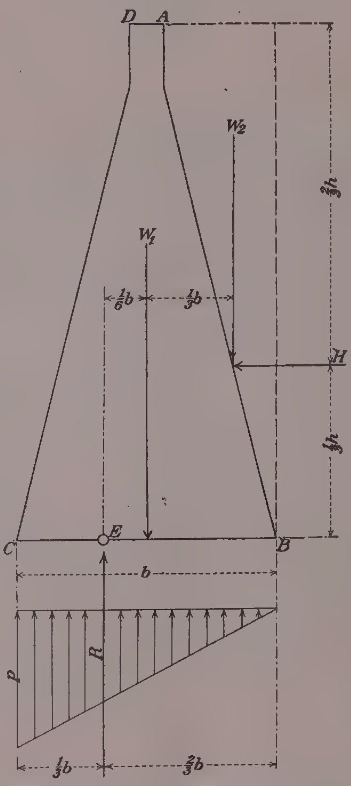


Fig. 3. Face and Back Battered.

Pressure on Foundation.—Many engineers in considering resisting and overturning moments of a retaining wall take center of moments about C, the toe of wall. This is perfectly justified if they consider all the forces acting, which, however, is not always done. From elementary mechanics we have the following three equilibrium equations for any body at rest under the action of several forces:

TABLE 3.—WIDTH OF BASE, TYPE 2.

Angle of Repose.			Width of Base, b.
Slope.	Deg.	Min.	
¼–1	75°	58′	$0.123\,h$.
½–1	63°	26′	$0.236\,h$.
1–1	45°	00′	$0.414\,h$.
2–1	26°	34′	$0.618\,h$.
3–1	18°	26′	$0.721\,h$.

1. $\Sigma H=0$. where ΣH represents the algebraic sum of the horizontal forces acting.

2. $\Sigma V=0$. where ΣV represents the algebraic sum of the vertical forces acting.

3. $\Sigma M=0$. where ΣM represents the algebraic sum of the moments.

To satisfy Equation 1, we have

1a. $H+F=0$, or $H=-F$, where F represents the frictional forces resisting sliding.

2a. $W+R=0$, or $W=-R$, where $W=$ weight of force acting downward, and $R=$ resultant foundation pressure acting upward.

Taking moments about C, we have

$$Hh/3-2/3\,b\,W+1/3\,b\,R=0.$$

TABLE 2.—WIDTH OF BASE, TYPE 1.

Angle of Repose.			b for $m=150$ lb.			b for $m=120$ lb.		
Slope.	Deg.	Min.	$w=100$	$w=120$	$w=140$	$w=100$	$w=120$	$w=140$
¼–1	75°	58′	$0.1005\,h$.	$0.11\,h$.	$0.119\,h$.	$0.1123\,h$.	$0.123\,h$.	$0.133\,h$.
½–1	63°	26′	$0.193\,h$.	$0.211\,h$.	$0.228\,h$.	$0.216\,h$.	$0.236\,h$.	$0.255\,h$.
1–1	45°	00′	$0.338\,h$.	$0.370\,h$.	$0.400\,h$.	$0.378\,h$.	$0.414\,h$.	$0.447\,h$.
2–1	26°	34′	$0.505\,h$.	$0.553\,h$.	$0.597\,h$.	$0.565\,h$.	$0.618\,h$.	$0.668\,h$.
3–1	18°	26′	$0.589\,h$.	$0.645\,h$.	$0.696\,h$.	$0.659\,h$.	$0.721\,h$.	$0.779\,h$.

NOTE:—The maximum shear is 7500 lb. per square foot, or 52 lb. per square inch, for walls of the proportions given in this table.

It is much more convenient, however, to take moments about E distant $1/3\ b$ from C, when we have

$$1/3\,hH-1/3\,bW=0 \text{ or } Hh=bW.$$

If we take moments about C and neglect the moment $1/3\ bR$, which is often done, we must assume that R has no lever arm, and hence acts through C. This is assuming that all the foundation pressure is concentrated at the toe of the wall, which is not in accord with the accepted theories of stress distribution. To the writer, it seems most logical to assume a distribution of stress from a minimum at B to a maximum at C. He will readily admit that if the wall began to tip, the pressure could vary from a maximum at C to a minimum at some point between C and B. Such a distribution of pressure is very probable so long as the crushing strength of the masonry or foundation at C is not exceeded. However, the writer's method is on the side of safety, and will be used in the following discussion. The resisting moment of the wall will, therefore, be regarded as the moment of the weights of wall and superincumbent material about the point E.

TABLE 4.—WIDTH OF BASE, TYPE 3.

Angle of Repose.			b for $m=150$ lb.			b for $m=120$ lb.		
Slope.	Deg.	Min.	$w=100$	$w=120$	$w=140$	$w=100$	$w=120$	$w=140$
¼–1	75°	58′	$0.1007\,h$.	$0.1051\,h$.	$0.1087\,h$.	$0.106\,h$.	$0.1102\,h$.	$0.1136\,h$.
½–1	63°	26′	$0.193\,h$.	$0.201\,h$.	$0.208\,h$.	$0.203\,h$.	$0.211\,h$.	$0.217\,h$.
1–1	45°	00′	$0.338\,h$.	$0.353\,h$.	$0.364\,h$.	$0.356\,h$.	$0.370\,h$.	$0.381\,h$.
2–1	26°	34′	$0.505\,h$.	$0.527\,h$.	$0.545\,h$.	$0.532\,h$.	$0.553\,h$.	$0.569\,h$.
3–1	18°	26′	$0.590\,h$.	$0.615\,h$.	$0.636\,h$.	$0.620\,h$.	$0.645\,h$.	$0.665\,h$.

The following three types of gravity walls will be considered:

Type 1.—Wall with back vertical and face on a batter.

Type 2.—Wall with face vertical and back on batter.

Type 3.—Equal batter on both face and back.

Type 1.—(Fig. 1).

The weight of the wall $=hbm/2=W_1$

$$M_r=W_1b/3=hb^2m/6$$

The value of the overturning moment, as shown in table 1, varies with the angle of repose assumed. Let the value of $M_t=awh^3$, where values of a are as given in table 1, then

$$hb^2m/6=awh^3 \text{ or } b^2=6awh^2/m$$

or

$$b=h\,(6a)^{\frac{1}{2}}\ \sqrt{(w/m)} \qquad (3)$$

Hence b varies directly with the square root of w, and inversely with the square root of m.

In table 2 are given the values of b in terms of h for varying values of ϕ and w and m. If further values of m or w are deemed necessary, the corresponding value of b can be computed by (3), or by direct interpolation from table 2.

Type 2.—(Fig. 2).—The center of gravity of the triangular portion BCD of the wall acts at a distance $1/3\ b$ from the face. Hence the resistance to overturning is furnished by the earth backing and the friction along the back AB, which friction is neglected in these computations.

The overturning moment as in type 1 equals $M_t = awh^3$. The weight of the earth which resists overturning $= whb/2 = W_2$, and $M_r = W_2 b/3 = whb^2/6$.

$$M_r = M_t \text{ or } whb^2/6 = awh^3 \text{ or } b^2 = 6ah^2$$

$$b = h\sqrt{6a} \qquad (4)$$

Hence b is independent of w and m.

Table 3 contains the required values of b to insure stability for this type of gravity wall.

Type 3.—(Fig. 3).—Equal batter on both face and back.

The weight of the masonry wall for this type $= \frac{1}{2}bmh = W_1$. The weight of the earth backing $= W_2 = \frac{1}{4}bhw$. The overturning moment of the earth, as in types 1 and 2, is $M_t = awh^3$. The resistance to overturning is furnished by W_1 and W_2 and equals

$$M_r = W_1 b/6 + W_2 b/2 \text{ or}$$

$$M_r = \tfrac{1}{2}bhm\, b/6 + \tfrac{1}{4}bhw\, b/2.$$

$$M_r = (m/12 + w/8)\, b^2h = (2m + 3w)\, b^2h/24.$$

$$M_r = M_t \text{ or } awh^3 = (2m + 3w)\, b^2h/24$$

$$b^2 = \frac{24\, awh^2}{2m + 3w} \text{ or } b = h\sqrt{\frac{24\, aw}{2m + 3w}} \qquad (5)$$

Table 4 contains the required values of b to insure stability for this type of gravity wall.

Comparison of the Three Types.—Tables 2, 3 and 4 show that a gravity wall of type 2 requires a greater width, *b*, and hence more masonry than either type 1 or 3. When the weight of the masonry is 150 lb. per cubic foot, and the weight of the earth is 100 lb. per cubic foot, types 1 and 3 require the same width of base, and hence the same amount of masonry. With lighter masonry and heavier earth, however, type 3 becomes the economical type of gravity wall as far as quantity of masonry is concerned. Type 1, however, requires the least amount of excavation. This saving in excavation may, in many cases, more than offset the cost of additional masonry. The relative total cost of the two types may be readily estimated for any given case.

Type 2 is the least economical of the three types in both the matter of excavation and masonry. However, local conditions often demand that the face of the wall be vertical.

[To be continued.]

THE APPRENTICE SCHOOLS established at the leading shops of the Sante Fé System by direction of Mr. J. W. Kendrick, second vice-president, have proved unusually successful in raising the quality of work done by the boys. Each apprentice is required to attend school regularly 2 hours a day for 2 or 3 days in the week, where he is taught the elements of shop arithmetic, elementary mechanics and free-hand and mechanical drawing. All the drawing instruments are furnished by the company. The instruction is of a thoroughly practical character and is uniform in all of the shops, the lesson papers being prepared in the offices of supervisor of apprentices, whose headquarters are at Topeka. The boys are paid at their regular rate while attending the school. Their work in the shops is supervised by instructors, one instructor being provided for every 20 boys. He shows them how to use the machine tools and transfers them from one machine to another, so that they may have the best training, or, in case of rush work, the instructor may place one of the more advanced apprentices on a machine and help him on the work, thus assisting the foremen. These instructors are selected from the best men in the shops and as a result of their care and of the school training, about 25 per cent. more work is done by the average apprentice now than formerly, and the young men are taught Santa Fé ways from the outset. Boys who violate the rules are given demerits and 60 such marks result in expulsion. Credit marks for exceptional work are also given.

Notes on Two Recent Tests of Fuel Oil Pumping Engines.

The towns of Wrentham and Wareham, Mass., have installed municipal water supply systems during the past year. In both instances water is drawn through a group of 2½-in. tubular wells, averaging from 29 to 36 ft. in depth from the natural surface of the ground to the top strainer hole. The elevation of the floors of the pumping rooms was made as low as possible, in both cases only about 18 in. above mean ground water level, in order to reduce the suction lift to a minimum.

At Wareham the strainers on the wells penetrate a coarse water-bearing gravel stratum, through which the water flows freely, with very little friction. The yield of the individual wells, with a No. 3 Edson diaphragm pump, ranged from 40 to 70 gal. per minute in the preliminary tests.

At Wrentham, by reason of the location of the wells, the water flows freely out of the 2½-in. pipes when cut off about 1 ft. above the natural surface of the ground, so that the water from this source rises naturally to an elevation nearly as high as the center of the suction main to the pumps. In this case the material encountered is gravel of finer quality than that encountered at Wareham.

In both installations the suction main is fitted with a Smith sand chamber, set in a specially constructed concrete manhole, so designed as to drain freely when blowing out the chamber. Both pumping stations are practically of the same design throughout and have the same floor space, 25 x 36 ft. At Wareham there are installed two 25-h.p., two-cycle Mietz & Weiss fuel oil engines, fitted with compressed air starting device, with pressure from the force main, and with two 8 x 10-in. vertical, triplex, single-acting Smith-Vaile plunger pumps. At Wrentham there is installed at present one unit similar to the above, but a second similar unit is to be installed during the coming season. In both cases rawhide pinions are used, and the driving shafts are so arranged that either pump can be operated by either engine, or both pumps may be operated at the same time. These pumps are designed for a capacity of 250 gal. per minute at a normal speed of 40 r.p.m.

The plant at Wrentham was subjected to a test on March 4, covering a period of six hours. The fuel oil tank was filled to within 1¼ in. of the top at the start and was brought to the same level after the test had been closed, all of the oil put into the tank in the meantime being carefully weighed. Ordinary fuel oil, purchased through the Standard Oil Co., was used, averaging in weight 7½ lb. per gallon and costing approximately 5¾ cents per gallon, delivered at the station. The station is 1½ miles from the freight siding.

Making an allowance of 1 per cent. for slip, the net displacement of the pump per revolution was determined to be 6.46 gal. The total number of revolutions was 14,616, or an average of 40.6 r.p.m. The average capacity of the pump was 262.28 gal. per minute, or a total of 94,419.36 gal. in the six hours. The average pressure pumped against was 77.625 lb. per square inch., and the average vacuum on the suction main was 13.2 in. The total average height to which the water was lifted, after correcting for the difference in elevation between the gauges and the suction and force mains, was 197.88 ft., equivalent to 85.88 lb. per square inch. The average temperature of the water pumped from the wells was 48 deg., corresponding to a weight per cubic foot of 62.41 lb. The total work done by the engine on the pump end was 155,888,912 foot-pounds, equivalent to an average of 13.122 h.p., or a total of 78.732 h.p.-hours.

The total oil used during the run was 153.25 lbs., and the fuel oil consumption per horse-power per hour, based on the horse-power delivered at the pump end, was 1.95 lb. No test was made to determine the horse-power actually developed by the engine, but, assuming a pump efficiency of 70 per cent., the fuel oil consumption was 1.36 lb. per horse-power per hour.

Under the conditions of this test the cost of pumping 1,000 gal. of water was 2.06 cents, and the cost of raising 1,000,000 gal. one foot high was 10.4 cents.

The engine was cold before starting the above test, and it required about 19 minutes before water was pumped under full pressure.

The plant at Wareham was subjected to a test on March 7. The fuel oil tanks were filled to within 1 in. of the top at the start of the test, were brought to the same level at the conclusion of the test, and all of the oil used was carefully weighed. Ordinary fuel oil, purchased through the Standard Oil Co., weighing 7.5 lb. per gallon and costing approximately 7 cents per gallon, delivered at the station, was used. The station is about 3 miles from the freight siding.

Making an allowance of 1 per cent. for slip, the net displacement of the pump per revolution was 6.46 gal. The two units were tested separately, and the following figures show the average results of both tests.

The average pressure pumped against was 80.6 lb. per square inch, and the average vacuum was 11.1 in. Correcting for the difference in elevation between the gauges and the suction and force mains, the total average height to which the water was lifted during the test was 201.11 ft. The average temperature of the water pumped from the wells was 49 deg., giving an average weight per cubic foot of 62.4 lb. The average work done on the pump end was 87,901,360 ft.-lb., equivalent to an average of 13.35 h.p. The first test covered 3 hours and 9 minutes and the second test 3 hours and 30 minutes, giving an average of 44.393 h.p.-hours. The average total oil used was 85.575 lb., giving an average of 1.935 lb. per horse power per hour, based on the horse-power delivered at the pump end.

No test was made to determine the horse-power of the engines, but on the assumption that the pump efficiency was 70 per cent. the average fuel oil consumption was 1.36 lb. per engine horse-power per hour.

Based on the above test, however, the average cost of pumping 1,000 gal. under the conditions prevailing during the test was 2.38 cents. Under the same conditions the cost of raising 1,000,000 gal. one foot high was 11.83 cents. Both engines were cold before starting the test and it required about 18 minutes in each case to start pumping under full pressure.

Both at Wareham and at Wrentham the operation of the engines was very satisfactory, the explosions regular and the exhaust steady. Both systems were designed and constructed under the supervision of Mr. Edmund M. Blake, Boston, Mass. The Wrentham system, containing 5.643 miles of cast-iron mains, cost approximately $50,000. The Wareham system, containing 5.42 miles of cast-iron mains, cost approximately $56,000. Mr. Blake made a second test of the Wareham pumps on April 21, and the following notes regarding it are taken from his report.

The oil used, ordinary fuel oil bought through the Standard Oil Co., was approved by the builders, and all measurements of oil used in the test were carefully checked. This oil when tested showed a specific gravity of 0.87, equivalent to 7.25 lb. per gallon, which weight was also checked by actual measurements on accurate platform scales. At 60° Fahr. this oil gave 32 deg. on the Beaumé scale, and at the ordinary temperature taken directly from the oil barrels, gave 30 deg. on the Beaumé scale.

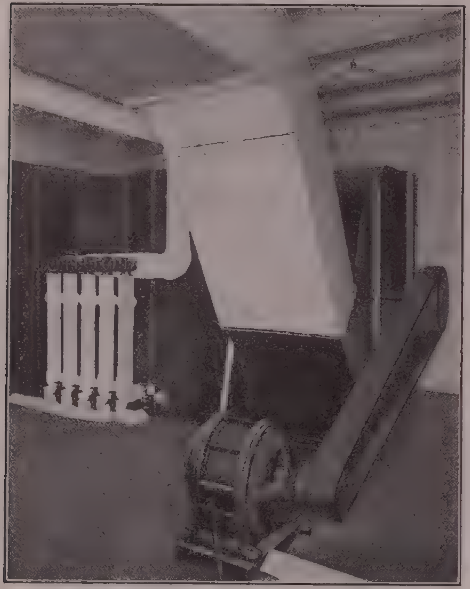
The test on the north unit covered a period of 3 hours and 30 minutes. Readings were taken every 15 minutes on the engine counter, on a test pressure gauge located on the force main between the check valve and the north pump on a test vacuum gauge located on the main suction line and on the regular vacuum gauge located on the suction inlet to the north pump. Frequent readings were taken of the temperature of the water pumped from the wells and of the temperature of the engine room. The amount of oil used for lubricating was also carefully determined during the progress of the test.

The fuel oil tank was filled to within ¾ in. of the top at the start of the test, was filled up to the same mark after the test, and all of the oil used in the meantime was carefully weighed.

The plunger displacement of the pump, making an allowance of 1 per cent. for slip, was 6.46 gal.

The total number of revolutions made during the 3½ hours was 8,460, or an average of 40.3 r.p.m. The average capacity of the pump for this period was 260.34 gal. per minute, or a total of 54,651.6 gal. in the 3½ hours.

The pressure on the force main was regulated by throttling the stop gate and was kept at an average of 102 lb. per square inch throughout the run. The average vacuum on the suction main, made up of the average of the readings on the two vacuum gauges, was 10.9 in., which happens to be exactly the same as the average vacuum determined in the test of the north unit on March 7. Allowing for the difference in elevation between the center of the pressure gauge and the center of the force main, adding the difference in height from the center line of the suction main to the center line of the force main, and correcting for the difference in elevation between the center line of the vacuum gauges and the center line of the suction main, the total average height to which the water was lifted during the run was 249.86 ft., equivalent to 108.44 lb. per square inch, which represents the pressure against which the engine was required to pump the water.



A Blower and Heater Equipment.

The average temperature of the water pumped from the wells was 49 deg., exactly the same as on March 7. The total quantity pumped, 54,651.6 gal., is equivalent to 7,306.37 cu. ft. This means that 455,917.49 lb. of water were lifted to a total height of 249.86 ft., representing an equivalent in work done by the engine of 113,915,544 ft.-lb. This in turn is equivalent to an average of 16.44 h.p. throughout the run, or a total of 57,540 h.p.-hours.

The total fuel oil used during the run was 98 lb. The duty performed by the engine in foot-pounds of work done per 100 lb. of fuel oil was 116,240,000. The fuel oil consumption per horse-power per hour, based on the horse-power delivered at the pump end, was 1.70 lb., as against 2.05 lb. on March 7.

Assuming a pump efficiency of 70 per cent., the horse-power developed by the engine was 23.48 h.p., equivalent to 82.180 h.p.-hours for the run, upon which basis the fuel oil consumed per horse-power per hour for the engine end was 1.19 lb., as against 1.44 lb. on March 7. On the assumption of 70 per cent. efficiency for the pump, the engine was operating at 93.92 per cent. of full load.

The test on the south unit also covered a period of 3½ hours and was conducted like that just described. The fuel oil consumption per horse-power per hour, based on the horse-power delivered at the pump end, was 1.70 lb., or exactly the same as in the case of the north engine, as against 1.82 lb. on March 7.

Assuming a pump efficiency of 70 per cent., the horse-power developed by the engine was 22.32 h.p., equivalent to 78.12 h.p.-hours for the run, upon which basis the fuel oil consumed per horse-power per hour for the engine end was 1.18 lb., as against 1.28 lb. on March 7. On the assumption of 70 per cent. efficiency for the pump, the engine was operating at 89.28 per cent. of full load.

Overhead Duct Distribution System, Yonkers Battery House.

The above two tests were not run under conditions which will be met in every day service, and therefore the costs of pumping have no direct bearing on the economy of operation which will prevail during regular pumping. The object of the tests was to try the engines out at nearer their full load.

Following the test of the south unit, both pumps were operated in unison, with a combined discharging capacity based on the two previous tests of 365,760 gal. per 24 hours. Before starting both pumps together the static pressure in the force main, the standpipe being practically full, was 62 lb. per square inch. With both pumps operating, this pressure was raised to 80 lb. per square inch, showing a friction equivalent to 18 lb. per square inch. During the running of the two pumps together the average vacuum of the walls rose to approximately 19 in.

The State Ownership of Waterfalls, which was made possible in Sweden by appropriations in 1906, is to be still further extended if the government grants a recent request made by the Board of State Railways for $1,800,000. The water powers now owned seem to be sufficient for immediate needs, but the board takes the position that those waterfalls which will eventually be needed for the extensive electrification of the state railroads, should be secured while there is a chance of getting them.

Heating and Ventilating Equipment for Storage Battery Buildings.

In connection with the electrification of the New York City terminal divisions of the New York Central & Hudson R. R., a number of large storage battery plants were installed at distributed points, for purposes of reserve for the third-rail propulsion-current supply. Five of these equipments have been installed in separate battery buildings, one at both the Yonkers and the Port Morris power plants of the system, and one each at the Bronx Park and Kingsbridge stations and on Lexington Ave. in the city near Grand Central Station. An unusual feature of the battery equipment is the guarantee that was given by the company which installed them that is drawn to extend over a term of 10 years, provided only that the temperature in the battery houses be maintained constantly at 70 deg. Fahr., and in order to secure the advantage of this guarantee, the railroad company provided for heating plants in all of the buildings by means of which the constant temperature could be maintained in cold weather, as well as cooling in warm weather and ventilation at all times.

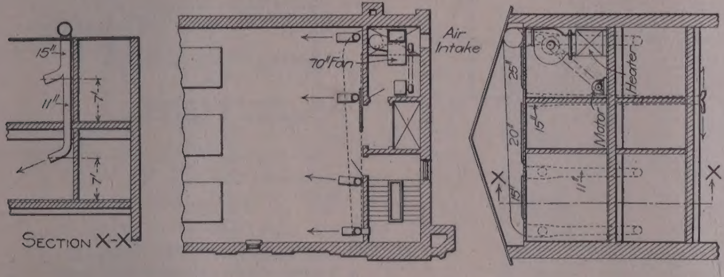
A difficulty of considerable magnitude was, however, encountered in the installation of such equipment in the effect of the destructive acid fumes that are given aff from the storage battery cells while under charge, which rendered impracticable the use of direct radiation in any form. No kind of metal pipe or radiation can be used without rapid destruction from corrosion unless too heavily covered with protecting material to be effective for heating purposes, it being, in fact, necessary to carefully protect all details of the building construction from the fumes by inert covering materials. This difficulty pointed at once to the use of the blower system which offers the advantages for these conditions of indirect heating and constant ventilation of the rooms served, of the acid fumes. With this system, the equipment may be placed entirely outside of the battery rooms and only the air delivery connections need enter the latter, which may be amply protected from corrosion by the acid fumes. As a result, blower systems have been installed in each of the five battery stations—the first of the kind to be used under such conditions.

The equipments vary in size considerably, but are all proportioned to effect complete changes of air in the battery rooms in from 9 to 12 min. The battery house at the Bronx Park Sub-station which is typical of the battery installations at sub-stations is shown herewith. The equipment of this house consists of a 90-in. fan and tempering coils, the fan here supplying air to 27 x 106 ft. battery rooms on two floors and in addition to small locker and toilet rooms adjacent. This fan is operated by a 10-h. p. General Electric motor at a maximum of 400 r. p. m., at which speed it has a delivery capacity of approximately 13,000 cu. ft. per minute. In the station at Lexington Ave. and Fiftieth St. in the city, also illustrated herewith, a 70-in. fan is installed, as this equipment supplies only the battery rooms on two floors, which are 17 x 76 ft. in plan. This fan is driven by a 7½-h. p. General Electric motor at 500 r. p. m., at which speed it has a delivery capacity of 9,000 cu. ft. per minute. The fans are all full-housed steel-plate blowers and the tempering coils, box-base sectional pipe heaters, all of which were supplied by the American Blower Co. Steam is supplied to the coils at the sub-stations by low-pressure cast-iron heating boilers, but from the power stations in the case of the two battery buildings located adjacent to them. The equipments of the three other stations are similar to those here shown with the exception of the two battery buildings adjoining the main power stations in which controller chambers, bus-bar chambers, corridors and stair halls are ventilated in addition to the battery rooms.

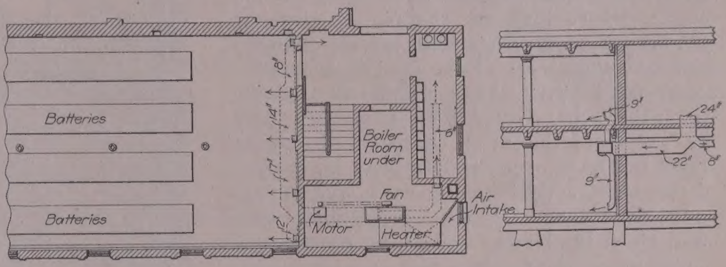
As to methods of distribution of the air in the battery rooms, however, two different methods have been employed, one consisting of blowing in air at one end of the battery room and the other of distributing through the rooms by ducts with branches therefrom at frequent intervals. The latter was employed in the battery house adjoining the Yonkers power station only and consists of galvanized-iron duct work which is protected by a special preparation of acid-proof paint thoroughly applied. The appearance of the duct work at this station is shown in an accompanying illustration; the trunk duct shown is on the ceiling of the first floor and from it the side branches are shown extending to either side wall and down to a point near the floor for the first floor outlets and through the floor above for the second floor supply. In the other battery buildings, there is no distribution duct work within the battery rooms, the air being delivered to them through a number of outlets at the end nearest the fan room as indicated in the accompanying drawings; in these cases the delivery outlets consist of tiled conduits terminating in registers formed of a composition of 95 per cent. of lead and 5 per cent. of antimony, which is calculated to effectively resist the action of the acid fumes. In all of the cases, the exhaust of air from the battery rooms is provided for through small cast-iron gratings over the window casings.

It is interesting to note that the results from the systems in operation, have shown that the method of blowing in air at one end of the battery rooms only is fully as satisfactory as that involving the duct distribution system. It is found that with the former, there is no difficulty in maintaining the temperature constant in all portions of the battery rooms, the temperature control being in the care of attendants who adjust the amount of heating surface in the tempering coils from time to time in order to maintain the battery rooms at 70 deg.; the fans are operated at constant delivery volumes at all times, regardless of the requirements for heating, in order to secure the advantages of ventilation. One advantage of the method of blowing in at one end is evident from the interior views, the absence of duct work on the ceiling being conducive not only to the appearance of the room, but also to a considerable economy in minimizing the cost of maintenance and renewal of the lines of ducts.

These heating and ventilating systems were designed by the American Blower Co., Detroit, Mich., and the equipments were installed by John Hankin & Bro., heating contractors, New York



System at Lexington Avenue and Fiftieth Street.



System at the Bronx Park Battery Station.

Letters to the Editor.

LIVING CONDITIONS AT PANAMA.

Sir: The special labor commission sent to Panama a couple of months ago by President Roosevelt has just finished its labors, and if its report is made public it will prove a valuable addition to the already voluminous official papers on the Isthmian Canal. The labor commission comprised Mr. James B. Reynolds, the well-known New York lawyer and close friend of the President, Mr. S. B. Donnelly, secretary of the joint association of master builders and labor unions which has been very successful in reducing strikes in New York, and Mr. H. B. Needham, of Washington, whose work in social economics has attracted much attention. These gentlemen have been working energetically and overtime ever since they reached the Isthmus, and what they have to say about the conditions there will deserve careful attention. The following notes on living conditions are based on such examinations of the quarters and the food as the writer could make conveniently while studying the construction methods followed at the Isthmus, and on official reports and the statements of men of many grades. They are necessarily incomplete, but it is hoped they will show the care that the Commission exercises for the comfort of its employees and will enable the reader to compare the working conditions at the Isthmus with those on other large construction enterprises.

There are three classes engaged on the canal work, the negro "silver" laborers, the white "silver" laborers, and the white "gold" employees. The negro laborers come mostly from Jamaica and the other West Indian islands, and they form the larger proportion of the unskilled working force. Now that the method of managing them so as to develop their utmost efficiency has been learned, there are not so many complaints about them as formerly, and it is safe to say that they will remain the mainstay of the labor organization until the work is done. They are paid, as a rule, 20 cents silver (10 cents gold) per hour, about three times the rate they get at their homes, and while they probably will not average more than a year on the canal at one time, a great many of them return to the Isthmus after they have visited their homes. The troubles with them in early days were largely due to a failure to appreciate their extraordinary improvidence and disregard of rules of health. They would not eat enough wholesome food and they would not take the most elementary precautions against chills and other conditions to which the colored race in the tropics seems particularly susceptible, so that the grippe and pneumonia affected them to a considerably greater extent that it did the whites.

There are probably between 10,000 and 11,000 negroes now housed by the Commission and about 6,000 who live in little thatched huts. When one of these men marries he generally prefers to go out of the town a short distance to some hillside and there build a home for himself, which takes him and his wife but a short time. These huts are not so uncomfortable as they appear, for the thatch is water-tight and the sanitary inspectors insist on the surroundings being kept cleanly. Many of the married negro employees live in quarters built for them by the Commission or remodeled from the old French quarters which exist in a fair state of preservation along many parts of the line. These married quarters for negroes, which are furnished free, are better than the quarters they have on Southern plantations, and they are not so crowded as the tenements in the San Juan hill district in New York City. The unmarried negroes sleep in barracks which are kept clean by a force of janitors who have no other duties. Nobody is allowed to loaf about these quarters in working hours, and consequently they can be kept clean without any trouble. If a laborer does not feel like working he must either report to the doctor or go away from the camps, a rule which accomplishes a great deal of good. The sleeping quarters are admirably arranged to afford plenty of room in the barracks in the day time and comfortable beds at night. The beds are canvas cots folding up against posts during the day and lowered down at night like the top berth in a sleeping car. The food for these unmarried colored laborers is furnished for 30 cents (gold) a day at kitchens managed by the Commission, and the money for this subsistence is deducted from the men's pay. This plan was adopted to insure the proper nourishment of these laborers and has worked well. The food is prepared by cooks who know what the men like and is under a system of regular inspection to insure the maintenance of its quality and quantity. The men have large open rooms with tables and benches where they can eat protected from the weather, and these rooms are cleaned thoroughly every day. The married negroes obtain their food supplies from the commissaries run at cost by the Commission and from markets, some of which are under the supervision of the Commission, through the Panama Railroad Co., and housed in its buildings, while others are run by Chinese or Panamanians and are apparently not so closely inspected, although they are kept clean and all meats are under screens.

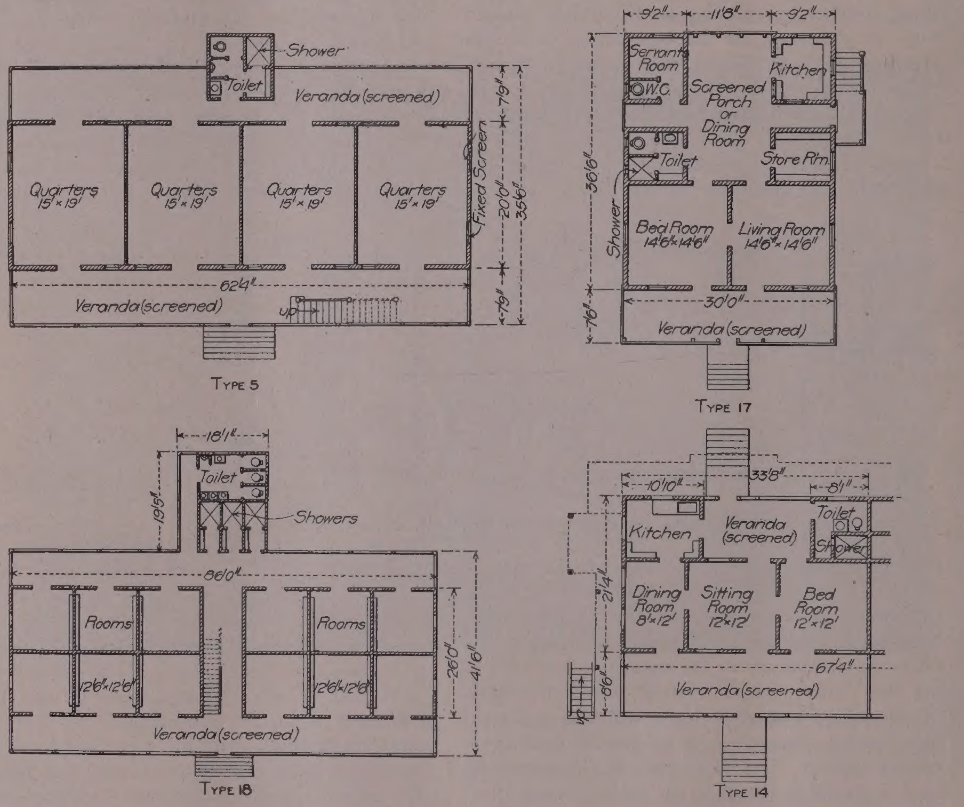
The white unskilled laborers number about

5,000 and have been brought from Spain and Italy. Their average pay is 20 cents gold an hour, which is probably about two and a half or three times what they earn at home. They are more effective laborers than the negroes, particularly when they are well handled, and the writer has seen them working on the tracks and on the dumps when the rain was descending in torrents, apparently unconcerned by the complete drenching they were getting. There are very few places along the line where active work is in progress where men cannot obtain shelter from the storms, but it takes a heavy storm to drive these white laborers there when important work must be done. They will sometimes shelter themselves under cars, which serve the purpose well, rather than walk farther to the sheds, and it may be said here that this whole problem of sheltering the laborers on the work has been greatly exaggerated by critics who fail to appreciate the real needs of laborers in a tropical country. If they have any complaints to make they can go to a special official whose time is devoted solely to looking after their welfare, and this official takes the complaints to Secretary Bishop of the Commission if they have any reasonable grounds.

The men live in barracks like those for the unmarried negroes and most of them eat at messes, where they are charged 40 cents a day. A few of them maintain messes of their own where the cost of the food is generally somewhat higher. At a Commission mess which the writer visited while dinner was being prepared, the meal consisted of coffee which had been over-burnt to meet the tastes of this class, a thick soup, a stew, vegetables and half a loaf of bread. Everything was clean about the kitchen and eating room.

The labor problem has been helped along by the presence of these white laborers. Before they were employed there was a tendency on the part of the negroes to shirk, particularly during rains, but after the Europeans reached the Isthmus and changes were made in the regulations regarding stopping work for showers, the negroes have shown a much better spirit. The superintendents in several places reported that by working a gang of Europeans near several negro gangs the latter were given an object lesson they gradually absorbed and eventually followed. Another reason for the improvement is doubtless the better class of foremen in charge of the gangs. At the outset these men were largely tropical floaters, not inclined to work themselves and given to the foulest language toward the men. They have been gradually replaced by more intelligent and capable foremen, who get more work from the men by encouraging rather than by abusing them. There is one aspect of the use of large numbers of Spaniards that deserves consideration on account of the unsettled political conditions in the Republic of Panama. Energetic revolutionists might incite these men to take part in an uprising, which is always possible in Central America, and thus involve the United States in international complications. Furthermore, if a number of them should get into a row in either Panama or Colon during a holiday, nobody can tell what troubles might ensue, for these men are very clannish husky fellows, while the Panamanian police are a pretty competent body of ex-soldiers. A good many people on the Isthmus accordingly believe that there are enough European laborers there now.

The living conditions for Americans on the Isthmus now are entirely different from what they were eighteen months ago, and while former complaints may have been justified, the skilled force now on the Canal Zone are unquestionably better paid, better housed and better fed than on any construction work ever undertaken in the country. The men acknowledge this and state that it is this fact only that keeps them there. There is nothing about life in the tropics that is attractive to the average man, for he can live better for the same money at home than on the Isthmus. There is no loafing in a hammock with a mint julep in one hand, a long cigar in the other, and an attendant to fan away the flies; these conditions exist only in the advertisements of steamship tours. It is a long ways home, the continued heat makes people's nerves a bit sensitive, and the opportunities for amusement are limited. The government needs the best men there, and in order to get them it has had to pay high wages and give quarters and conveniences far beyond anything a contractor would offer in the States. If it should abandon this policy by cutting down wages or reducing the conveniences now given, there would be an exodus of the best men from the Zone. Poorer men would take their places, and no reader of The Engineering Record needs to be told how the cost of construction mounts up when poor men handle steam shovels, construction trains, track, dredges and machine tools. The canal will be an expensive undertaking at the best, and the best way to save money will be to avoid any experiments with cheap skilled labor.



Type 5

Type 17

Type 18

Type 14

Floor Plans of Houses for Americans on the Canal Zone.

The married men on the Isthmus are given free married quarters, so far as possible, but although there are several hundred applications for such quarters still unfilled it is not likely that many more will be constructed, for reasons that need not be discussed here. Plans of two types of these houses are given in the accompanying diagrams. Type 14 is a two-story four-family house, the diagrams showing half of the first floor. The second floor is similar. There have been 142 of these houses built at an average cost of $7,566, or 14 cents per cubic foot. Type 17 is another favorite. It is a one-story one-family house costing 15.3 cents per cubic foot.

These buildings, like all others constructed by the Commission, are carried by 6x6 or 8x8-in. posts resting on a 12-in. concrete cube which is supported on footings usually about 2 ft. square and 1 ft. thick. All the foundation posts and the sills resting on them are creosoted or tarred to keep out the ants. The ground plans show the large veranda space, practically adding a room to the house, for many families use the veranda as a dining room. They are screened with brass or bronze wire, placed on the outside so that the woodwork may be cleaned from the inside. All doors are small and as few as possible, and every precaution is taken to keep mosquitos out of the house. The walls are covered on the outside with drop siding and inside they are made of matched and dressed ceiling, set vertical. The ceiling of the rooms is like the interior walls. Where practicable in kitchens and bathrooms, the upper part of the walls is left open for ventilation and protected from the rain by galvanized iron hoods. The roofs are galvanized iron. The windows are of the casement type and open in, the blinds opening out. Where a window is not protected by a veranda, the blinds are omitted and fixed screens are used to prevent the screens being left open.

Each family is supplied free of charge with a range, a double bed, two pillows, two kitchen chairs, six dining chairs, a chiffonier, two center tables, a mosquito bar, a refrigerator, a double mattress, a kitchen table, a dining table, a sideboard, a dresser, a bedroom mat and three wicker rocking chairs. This furniture costs the Commission about $140 and if more is desired the Commission sells it at cost. The Commission also furnishes water, ice, fuel and light free. Commissary supplies vary slightly from season to season, but they average about the same as in the larger cities in the country. This applies to clothing as well as to food.

The skilled men without families on the Zone live in quarters. The floor plan of Type 5, a two-story building, shows the arrangement of a small building of eight rooms costing about $6,247, while the floor plan of Type 18, a two-story building, shows the arrangement of a 24-room building costing about $11,596. Generally two men are assigned to each room, and sometimes three. There is more complaint about this than any other one feature of life on the Isthmus, although lack of facilities for drying the clothes of the men in bachelor quarters is also the ground of considerable complaint. It does not seem likely that Congress will furnish money for enough bachelor quarters to give each man a room, but it is understood that the Commission will endeavor to furnish facilities for drying the clothes of its gold employees, which is accomplished on the Isthmus by putting the garments in a closet with an electric light near the floor to supply heat.

The bachelors eat at hotels, where they pay 30 cents for each meal. The food is of good quality and very abundant, but trouble is experienced in securing good cooks, a difficulty that is also said to exist on Fifth Avenue and Michigan Avenue. The writer has never had so much good food for so little money as at these hotels, which is the most comprehensive concise statement of the service he knows how to make.

So far as the climate is concerned, it is not at all bad, but the continued heat throughout the year is gradually enervating and a man has to take a vacation after two years. The government gives 42 days in every year, plus sick leave and various allowances. While the days may be as hot as 90° and the rains may be heavy, the nights are cool and most men after becoming acclimated sleep under blankets throughout the year. There are club-houses run by the Y. M. C. A. at several large towns and Congress should help to build more, for they are a splendid influence for the good. There are good ball teams and general athletic teams, and it is astonishing to see the interest taken by the men in gymnastic exercises.

AQUARIUS.

THE WATER PROBLEM OF THE WEST.

SIR: "I shall be obliged, hereafter, in accordance with the policy stated in a recent message, to veto any water power bill which does not provide for a time limit and for the right of the president or secretary concerned to fix and collect such a charge as he may find to be just and reasonable in each case."

The above paragraph, quoted from a recent message of President Roosevelt to Congress, while strictly in accordance with the general policy of the present Administration tending towards the conservation of our national resources, has served to enunciate the novel and heretofore unproclaimed doctrine of the proprietary rights of the Federal Government in the waters of a flowing stream. Taken in connection with an assertion of the right to control, regulate and lease the waters originating within the boundaries of our National Forest Reserves, which has recently been advanced by the Forest Service of the Department of Agriculture, and of the already vast vested interests of the settler, irrigator, miner and hydro-electric developer, whose economic welfare is thereby involved, the enunciation of this novel principle has served to arrest the attention of our legislative bodies as well as that of the public in general.

Although the principles underlying the subject are, on the whole, not complex, unfortunately, they are generally but little understood and hence frequently confounded. Thus the representative from Indiana who, in a recent debate in Congress, insisted on the riparian rights of the United States to control the waters of the Western Forest Reserves undoubtedly was not aware that the riparian doctrine is not universally conceded throughout our States and Territories. Or the editorial writer in one of the New York dailies who, referring to our water resources, hoped "that the Supreme Court should, at an early date, define the respective rights of Congress and the States," did not know that these rights form an integral part of the constitution of our newer States, and have frequently been confirmed by our higher courts. In view, therefore, of this evident general unfamiliarity with the subject, the following brief consideration of the historical, physical, legal and economical conditions underlying the same is attempted.

From our common ancestry and colonial dependency, the riparian doctrine of the English common law, which guarantees to every proprietor of lands located on the banks of a stream, the use of the waters which flow in the stream on or adjacent to his lands, has been accepted as an established principle underlying all hydraulic legislation in the original thirteen States. Subsequently, with the tide of Western immigration, its sphere has been extended until it is now the recognized doctrine in all that territory lying between the Mexican Gulf and the Canadian border, and east of the Missouri River.

Negro Hut of Best Type, Canal Zone.

Within these limits, an area of approximately 1,672,000 square miles, subject to a universally distributed precipitation, varying from an annual mean of 45 in. along the Atlantic seaboard to 52 in. along the coast of the gulf; a territory where streams, rivulets or springs are an incident to every freehold, the adoption and perpetuation of the riparian principle was a natural consequence of its meteorological and physical conditions.

West of the northerly trend of the Missouri River, extending to the summit of the Rockies and thence across the great interior basin to the eastern slope of the Coast and Cascade ranges, lies that great expanse of semi-arid territory where the precipitation varies inversely with the altitude, ranging from an annual mean of 35 in. at an elevation of 800 to 1,000 ft. along the Missouri River boundary, to 7 to 10 in. at an altitude of 4,500 to 5,000 ft., and above which the precipitation is found to increase with the altitude, reaching a maximum of 20 to 28 in. along the summit of the range. In that portion of this territory bounded on the East by an imaginary line 200 to 250 miles west of the Missouri River, lies an expanse of approximately 640,000,000 acres wholly, or at the best, largely dependent for its daily wants on the stream or underground waters fed from the catchment area of remote mountain summits possibly hundreds of miles distant. Naturally, therefore, with the settlement and development of this territory, the riparian doctrine of the East was inadequate to meet its immediate requirements, and hence, the new and western doctrine of state control of waters—the doctrine of appropriation—was evolved and maintained.

Waiving further consideration of Eastern conditions as being irrevocably fixed by precedent as well as by natural phenomena, let us briefly examine the physical and legal aspects of the Western situation. In that vast expanse of territory acquired by the Louisiana Purchase, and its subsequent extension through settlement and conquest along the Pacific coast, the sovereignty and proprietorship to all lands lying within its borders, excepting those secured by previous private grant, passed to the United States. Upon the settlement and development of this extensive area, its segregation into political units, and their subsequent admission to the union of States, in order to assert and secure to them their constitutional prerogative, it has been a precedent observed in each Congressional Act of Admission to incorporate therein an assertion that the new State shall enter the Union on a basis of absolute equality with each of the original States. This right has been sustained by the Supreme Court of the United States as follows:

Pollard's Lessee v. Hagan (3 Howard 224); "The right of Alabama and every other new State to exercise all the powers of government which belong to and may be exercised by the original States of the Union must be admitted and remain unquestioned." Or, again, Illinois Central R. R. Co. v. Illinois (146 U. S. 435): "The State of Illinois was admitted to the Union in 1818 on an equal footing with the original States in all respects * * * * there can be no distinction between the several States of the Union in the character of the jurisdiction, sovereignty, and dominion which they may possess."

As a direct descent from the English common law, the older States, and in accordance with the above assumption of parity, the subsequent new States, have asserted and the courts have sustained their respective claims to the tidal waters and lands lying under the tidal waters within their boundaries. McCready v. Virginia (94 U. S. 394): "The principle has long been settled in this court that each State owns the bed of all tide waters within its jurisdiction." Also see Pollard's Lessee v. Hagan (3 Howard 229), and Smith v. Maryland (18 Howard 74).

The broader claim for State sovereignty over navigable as well as tidal waters has also been asserted and sustained. City of Mobile v. Eslava (16 Peters 259): "That such rivers (navigable river) are common for navigation and commerce and in the widest sense is free from doubt—that Alabama has jurisdiction and power over them the same as the original States have over their navigable waters is equally clear." Martin v. Waddell (16 Peters 411): "When the revolution took place the people of each State became themselves sovereign, and in that character hold the absolute right to all their navigable waters and the soil under them for their common use."

These claims, however, are recognized to be subject to the paramount and constitutional (paragraph 3, section 8) right of the United States to control and regulate commerce on the navigable waters, which has been defined by the courts as applying to the waters solely as water highways, and implies no title or ownership to the same. City of Mobile v. Eslava (16 Peters 277): "The United States then may be said to claim for the public, an easement for the transportation of merchandise, etc., in the navigable waters of the original States, while the right of property remains in the States."

By the English rule a stream is navigable as far as the tide flows. In the United States the limit has not been specifically defined, the assumption being that it is navigable as far as it is in fact, without limitations as to size of boat, season of year or allowance made for natural local obstructions, reefs, falls, rapids, which might subsequently be eliminated or relieved.

Although nominally based on the assertion of State parity, the Western States have failed to include in their adoption of the doctrine of sovereignty, the underlying common-law principle of riparian rights which in the East has served to limit and prescribe the sovereign powers of the same. Penna. v. Whitney and Belmont Bridge Co. (18 Howard 432): "The purely internal streams of a State which are navigable belong to the riparian owner to the thread of the stream, and, as such they have the right to use the waters and bed beneath for their private emolument, subject only to the public right of navigation."

On the contrary, the Western principle of appropriation has prevailed. This, a natural outgrowth of the conditions and necessities arising in the early mining days of California, and subsequently approved and sustained by the courts, has spread until it now forms the basis of the water laws of Montana, Wyoming, Colorado, Utah, Idaho, Nevada, Arizona and New Mexico, and in a prescribed form, acknowledging the prior rights of riparian owners, the laws of Nebraska, North and South Dakota, California, Washington, Oregon, Texas and Kansas.

The right of a State thus to elect whether the riparian doctrine or that of appropriation shall prevail is a privilege conceded and acknowledged by the United States Supreme Court. State of Kansas v. State of Colorado (par. 117): "It (the State) may determine for itself whether the common-law rule in respect to riparian rights or that doctrine which obtains in the West of the appropriation of water for the purpose of irrigation shall control * * * * Congress cannot enforce either rule upon any State."

As a corrollary to the above outline examination of the decisions of the higher court, it is evident that upon the admission of a State to the Union, the sovereign rights of the United States, in respect to the public lands and waters within its territorial boundaries, cease and terminate, and that thenceforth the interests of the United States are solely proprietary. Woodruff v. North Bloomfield Gravel Mining Co. (18 Fed. Rep. 772): "Thenceforth the only interests of the United States in the public lands was that of a proprietor, like that of any other proprietor * * * in all other respects the United States stood upon the same footing as private owners of land." United States v. Cornell (Mason's Cir. Ct. Repts. Vol. 12 p. 63): "But although the United States may well purchase and hold lands for public purposes, within the territorial limits of the State, this does not of itself oust the jurisdiction of sovereignty of such State over the land so purchased."

Have our Western States been justified in the exclusion of the riparian principle? Has the strict application of the doctrine of appropriation proved all sufficient? Evidently not, for although the principal of riparian rights and of appropriation are flatly contradictory and repugnant, yet in eight of our Western States an effort has been made to restrict the privileges of the latter by a limited application of the former principle. Thus the constitution of the State of Washington, Sect. 1, declares: "The State of Washington asserts its ownership to the beds and shores of all navigable waters in the State up to and including the tide of ordinary high tide, in waters where the tide ebbs and flows, and up and including the line of ordinary high water within the banks of all navigable rivers and lakes." While the State Supreme Court has asserted in Benton v. Johncox, 2459: "It is held by all the authorities that the right of the riparian owner to the flow of the stream by or across his land, in its accustomed channel is an incident to his estate, and passes by a grant of the land." Again, in California, where the principle of appropriation applies, the State Supreme Court has ruled, Lux v. Hagin (69 Cal. 259): "Hence the rights of riparian owners of lands, formerly public lands of the United States, are to be measured by common law. The waters of streams running through such lands are not subject to appropriation without compensation, after the grant from the United States." Variations of a similar character to the above are to be found incorporated in the laws of Oregon, Nebraska, Kansas, Texas and the two Dakotas.

In those States where the strict doctrine of appropriation prevails, the rights of the United States, as of all other proprietors, in respect to the waters of the State, are defined and are the same; while in that group of States which have adopted the composite doctrine, the anomalous condition has arisen that although the right of the United States in public lands is "strictly those of a proprietor," yet the riparian principle preserving the waters to the owners of the land does not apply "until after the grant from the United States," the United States being thus deprived of rights and privileges accorded all subsequent proprietors.

With the rapid settlement and development of the public domain, approximately 90 per cent. of which has taken place below an altitude of 5,000 ft., at the close of 1907 the United States still remained proprietor of 402,992,800 acres of public lands lying west of the Missouri River and exclusive of Alaska, 170,999,000 acres of which were at that time unsurveyed. Since the surveys of public lands, with the exception of those located in excessively rough and mountainous country, were completed many years ago, and since the above figure approximately corresponds with the total area of our Forest Reserves and National Parks, 151,602,881 acres, it may be assumed that this extensive tract of 171,000,000 acres distributed among some eleven States, represents the great mountainous precipitating and collecting area of the western half of our continent and upon which that great expanse of arid foot hills and plains, 816,000,000 acres, included within the boundaries of thirteen States, is dependent for its water supply. The United States may therefore claim exclusive proprietorship of the Great Continental catchment area and yet, as has been previously shown, by decree of the higher courts, has been deprived, in favor of the States, of the right to control, regulate or apportion for the benefit of the greatest number, the natural discharge originating on and flowing from the same.

It has been a custom followed by the United States Land Office when instituting surveys of the public lands, to omit from computation the floodwater area of any stream of consequence, say over 50 ft. in width, flowing through the legal unit surveyed, the adjacent fraction being thereafter known as Lot No. so and so, area .... acres, instead of the usual uniform section of 640 acres and its legal and natural fractions.

It is evident, upon the subsequent sale or grant of public lands, that the national government has thereby unwittingly reserved to their own use and proprietorship the bed of all streams of the larger class. As this condition is one which did not previously exist in the original thirteen States, the doctrine of State parity and consequent precedent cannot be construed to apply. Hence despite the declarations of the constitution of our Western States to the contrary, the beds of all streams of this character remain and are still a portion of the public domain.

We therefore have the anomalous condition arising from Federal control of the water surface as a water highway; the State sovereignty of the actual waters; the ownership by the United States of the bed of the stream; and the title of the individual to the banks above high water.

The framers of the water laws now prevalent in our Western States were undoubtedly guided in their undertaking, primarily by precedent of the older States, and secondly by an effort to adapt the same to meet the physical conditions and immediate wants of their individual territory. Unfortunately, they failed to grasp the fact that no single doctrine based on the limited premises available at that time could be sufficiently comprehensive to meet the subsequent and unforeseen development of their territory.

Thus the principle of appropriation, as originally outlined in California, was admirably adapted to meet the wants and stimulate the efforts of the early placer miner, but to-day placer mining in our Western States and Territories has been entirely suspended. Again, the doctrine of appropriation was undoubtedly a stimulus to the early irrigator. Since the productive areas of our river bottoms are usually to be found remote and above the corresponding section of the stream, in order to meet his requirements, it was therefore a necessity that the water be diverted some distance upstream from the point of its final application; hence the principle of appropriation served to protect the irrigator from the otherwise prohibitory expense of acquiring extensive intermediate areas of unproductive land.

Unfortunately the requirements and problems arising at the present day are both in scope and purpose much more complex than was anticipated by the framers of our early laws. To the ore miner the prior appropriation and remote diversion of upstream waters, has left extensive metaliferous areas adjacent to the course of the stream entirely deprived of the natural water resources essential for power and mill requirements. With the great increase of our agricultural population, the rights of the prior appropriator, although nominally limited by statute to "employment for beneficial purposes" still permits the wasteful use of the diverted waters to the detriment and exclusion of the subsequent riparian owner. In that vast system of hydro-electric development which is rapidly revolutionizing the manufacturing industries of the West, a development serving to distribute the potential energy of the flowing stream over an area included within a radius of 125 miles, a use of the natural waters whereby they are neither wasted, diverted or reduced in volume, an employment only successfully accomplished through the application of vast aggregations of capital, the right of a riparian proprietor, the fortunate possessor of a site for a future development, to hold and retain this natural asset of his property, pending its future exploitation on an adequate scale, stands jeopardized and open to attack from speculative appropriators or promoters of minor projects.

Although the position now taken by President Roosevelt is based on an assumption of federal sovereignty over our navigable waters—a prerogative neither conferred by the constitution nor affirmed by the courts—and that of the forest service, on the contradictory and antagonistic doctrine of riparian rights, they are both undoubtedly moves in the right direction. For it is high time that the primitive and chaotic water laws of our States and Territories should be so amended, even by the adoption of a new principle of law if necessary, as to meet the exigencies of our present day requirements and development.

William R. King.

A Single Cable Ropeway divided into a 13,100-ft. and a 9,000-ft. section has been built at the Asturiana mines in Spain. The total fall is 2,235 ft. in favor of the load, and the single rope used both for supporting and hauling, carries from 30 to 35 tons per hour. The fall, according to "The Engineer," London, is more than sufficient to run the ropeway, and the surplus power is absorbed by two water regulators, which, while allowing a great variation in the speed of the line, keep constant any speed desired without the use of friction brakes and attendants. A powerful hand brake is used for starting and stopping the line. The buckets hold 700 lb. of ore each. Steel towers, some as high as 82 ft., support the line. The maximum span is about 900 ft.